School of Public Health

A Physical Activity and Nutrition Intervention for Singaporean Women Aged 50 Years and Above: A Community-Based Randomised Controlled Trial

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Declaration

To the best of my knowledge, this thesis contains no material previously published by any other person except where due acknowledgment has been made. It contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted following the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007)—updated in July 2018. The proposed research study received human research ethics approval (approval number: HRE 2016-0366) from the Curtin University Human Research Ethics Committee. It is also registered on the Australian and New Zealand Clinical Trials Registry (trial no: ACTRN12617001022358).

The work described in this thesis was undertaken by the author and is original. The study design, ethics approval, study procedure, data collection and analysis, writing of manuscripts for publication and writing of the thesis were conducted under the supervision of Associate Professor Jonine Jancey, Professor Andy Lee and Doctor Tony James.

Abstract

Introduction

Physical inactivity and unhealthy eating habits are behavioural risk factors that lead to a rise in non-communicable diseases (NCDs). According to the World Health Organization in 2019, NCDs continue to be the leading cause of death in Southeast Asia, claiming 8.5 million lives annually. In Singapore, NCDs such as cardiovascular disease (CVD), cancer and type 2 diabetes (T2D) pose major health challenges with high mortality and morbidity rates. Type 2 diabetes ranked second-highest globally in terms of the proportion of diabetic patients in 2019. As a result of the alarming rate of NCDs especially diabetes in Singapore, the Ministry of Health declared a 'War on Diabetes' in late 2016. The declaration focuses on physical activity (PA), nutrition and health screening as fundamental prevention approaches to combat NCDs. To address the escalating NCDs, this study designs, implements and evaluates a community-based PA and dietary intervention targeting Singaporean women aged ≥50 years old to improve behavioural and metabolic risk factors of NCDs.

Compared to men, Singaporean women aged 50–69 years exhibited higher levels of abdominal fat and obesity and lower levels of desirable high-density lipoprotein-cholesterol (HDL-C), which protects against CVD. Studies reported these women had high levels of physical inactivity and sedentary behaviour as well as a high intake of saturated fat and sugary beverages, along with low fibre intake. Although such metabolic and behavioural risk factors put these women at risk of chronic diseases, there is a lack of intervention research in the prevention of NCDs for this target group. These women reside in high-rise flats and are frequent patrons of recreational centres (RCs) that are conveniently located at the void deck of these flats. Building health-promoting RCs with supportive infrastructure can encourage and motivate at risk Singaporean women to adopt regular PA and healthy eating practices. In consideration of the ageing population and increased prevalence of NCD risk factors among Singaporean women aged ≥50 years old, the Singapore Physical Activity and Nutrition Study (SPANS) aimed to develop, implement and evaluate a PA and nutrition behaviour change intervention for these women attending RCs in Singapore.

Methods

Social Cognitive Theory and the Social-Ecological Model underpinned the six-month community-based randomised controlled trial (RCT). The cluster RCT was implemented in 26 RCs located across five major geographical areas in Singapore. Recruitment occurred in staggered stages over 18 months from October 2016 to March 2018. The districts were randomly allocated to the intervention group (three districts, 14 RCs) or the control group (two districts, 12 RCs). A sample of 682 participants was randomised to an intervention (n = 351) or a control (n = 331) group. The intervention participants engaged in the SPANS program (PA classes, nutrition workshops and dietary counselling sessions), received health resources and social support from the program ambassadors, whereas the control participants received only a booklet on falls prevention. All participants completed pre- and post-test assessments.

Program ambassadors (13 final-year undergraduate students in nutrition, sports and wellness, two qualified nutritionists and a certified fitness instructor) were trained by the principal investigator (PI) in the principles of motivational interviewing techniques to support participants' behavioural changes and promote program adherence. Under the supervision of the PI, they were responsible for the coordination and implementation of the intervention program, activities and data management. The facilities and activities of the RCs were audited and face-to-face interviews with participants were implemented by the program ambassadors. Information gathered from the audits and interviews examined the acceptability and appropriateness of facilities and activities to support participants and motivate healthy PA and dietary habits.

Primary outcome measures consisted of PA, sedentary and dietary behaviours, fasting blood glucose and lipid profiles. Secondary outcome measures were anthropometric measurements, blood pressure (BP) and health-related quality of life (HR-QOL) indicators. Repeated outcome measurements were collected at baseline and six-month post-intervention and analysed using univariate statistics, followed by generalised estimating equations (GEE) modelling. Program ambassadors also documented process evaluation throughout the intervention to ensure the effectiveness of the

intervention program, resources and program ambassadors. Self-administered evaluation forms and exit interviews were conducted post-intervention to assess the suitability of the program and to identify improvements. Qualitative data were translated, transcribed, coded and categorised into specific themes, supported by selected quotes from the de-identified participants.

Results

A final analysed sample of 295 intervention participants (84% response rate) and 285 control participants (86% response rate) completed the six-month intervention. After controlling for confounders, the results from the GEE analyses confirmed that the intervention group displayed statistically significant mean increases in moderate-intensity PA (65.2 metabolic equivalent of task [MET] mins/week, $p < 0.001$), vigorous-intensity PA ($p < 0.001$) and total PA (1124 MET mins/week, $p < 0.001$) relative to the control group at post-test. Statistically significant improvements were observed in an increased mean intake frequency of fruit ($p = 0.001$), vegetables ($p = 0.049$) and wholegrains ($p = 0.041$), as well as a mean reduction in salt and salty sauce intake ($p = 0.042$) and sugary beverages ($p = 0.019$) by the intervention group relative to the control group. Moreover, the intervention group showed statistically significant mean reductions in systolic BP (3.68 mmHg, $p = 0.020$), diastolic BP (3.54 mm Hg, $p = 0.001$) and body fat percentage (2.13%, $p < 0.001$) when compared to the control group. For self-reported HR-QOL indicators, only statistically significant improvement was reported for ‘no bodily pain’ ($p = 0.039$) in the intervention group compared to the control group from baseline to post-intervention, after controlling for confounders.

Participants suggested improvements to the RCs such as an increase in the size of the facilities, customised activities with flexible timing and provision of motivators to maintain their RC engagement. They described the RCs as popular and easily accessible venues that increased communal connectedness and influenced their lifestyle practices. The process evaluation of the study displayed that regular modification of the program and resources with participants to suit their interests and needs were crucial to support their positive PA and dietary practices.

Conclusion

The SPANS represents the first RCT to examine the impact of a culturally relevant, community-based intervention to improve PA and dietary behaviours and health outcomes among Singaporean women aged ≥50 years old. It contributes to the knowledge base for PA and nutrition behavioural interventions targeting physically inactive Singaporean women who are at risk of developing chronic conditions. The GEE analyses confirmed that the program was efficacious in improving PA and dietary behaviours, with a significant reduction in systolic and diastolic BP and body fat percentage among the target group. A combination of the culturally appropriate program and resources with MI techniques delivered by the trained program ambassadors was an effective means to engage the participants in healthy lifestyle practices.

Given the rising NCD prevalence accompanied by unhealthy habits among Singaporean women, this study could be replicated and upscaled in other community settings as a promising primary prevention initiative before the onset of chronic conditions. Moreover, RC managers should consider practical suggestions provided by the participants for improving the facilities and activities of the neighbourhood RCs. Consequently, the support of policymakers and relevant stakeholders is essential to develop effective PA and nutrition interventions to encourage long-term behavioural changes and mitigate chronic diseases among at risk women.

Acknowledgments

I would like to express my sincerest appreciation and gratitude to the following people who have supported me with the development, implementation and evaluation of this research study, for which I am genuinely thankful.

First of all, I would like to express my sincere gratitude and appreciation to my supervisor, Associate Professor Jonine Jancey, for her patience, encouragement and support in guiding me throughout the whole research process. She was always readily available to discuss the challenges faced during the research study, and she always gave prompt, constructive feedback that enabled me to learn more about the whole research process.

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Statement of the Contributions of Others

The School of Public Health at Curtin University provided the research environment that supported the PhD candidate to undertake this research. The PhD candidate conceptualised, designed and pilot-tested the methodology and intervention, conducted recruitment, implemented the intervention program and was involved in managing and interpreting the data collection, management and analysis. The PhD candidate was responsible for writing all the chapters in the thesis and the associated publications. The respective co-authors provided their inputs for improvement in the thesis and the publications. Details are provided below.

- **Associate Professor Jonine Jancey** contributed as PhD supervisor and provided close supervision and monitoring of the research development, implementation and evaluation. She actively participated in the study, read drafts critically and suggested improvements for all the publications and the thesis.

- **Professor Andy Lee** contributed as PhD co-supervisor and provided statistical support and advice. He also participated in the study design and research process, read drafts critically and suggested improvements for all the publications and the thesis.

- **Dr Tony James** contributed as PhD co-supervisor and provided advice, ongoing support and was involved in all stages of the research study and process. He read drafts critically and suggested improvements for all the publications and the thesis.

  Appendix A provides signed statements of the contributions of each co-author listed above.

List of Publications

The following publications are included as part of this thesis (refer to Appendix B).

Publications in Print

1. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: Study protocol for a randomised controlled trial. *Trials,* 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2 [Impact factor: 2.185].

2. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational centres' facilities and activities to support healthy ageing in Singapore. *International Journal of Environmental Research and Public Health,* 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343 [Impact factor: 3.127].

3. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process evaluation of the 'Singapore Physical Activity and Nutrition Study'. *Evaluation and Program Planning,* 83, 101847. https://doi.org/10.1016/j.evalprogplan.2020.101847 [Impact factor: 1.519].

4. **Wong, E.Y.-S.,** James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: A cluster randomised controlled trial. *Asia Pacific Journal of Public Health.* https://doi.org/10.1177/1010539520977311 [Impact factor: 1.85].

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List of Conference Presentations

1. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. Physical activity and nutrition intervention for Singaporean women aged 50 years and above: A study protocol for a community-based randomised controlled trial, *International Conference on Physical Activity and Nutrition*, Bangkok, Thailand, August 2017 (Oral Presentation).

2. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. Are recreational centres promoting healthy ageing? *International Conference on Advances in Ageing Research,* Singapore, November 2018 (Oral Presentation).

3. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. Process evaluation of the Singapore Physical Activity and Nutrition Study, *International Conference on Health and Disease,* Singapore, January 2019 (Oral Presentation).

4. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. Singapore Physical Activity and Nutrition Study improves health outcomes for older adults in recreational centres: A randomised controlled trial, *Mark Liveris Student Seminar*, Perth, Australia, March 2019 (Oral Presentation).

5. Jancey, J., **Wong, E. Y.-S.,** James, A. P., & Lee, A. H. Recreational centres – supporting healthy ageing in Singapore. *Science on the Swan Conference,* Perth, Australia, June 2019 (Poster Presentation).

6. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. Effectiveness of a Singaporean Physical Activity and Nutrition Study: A clustered randomised controlled trial, *17th International Society of Behavioural Nutrition and Physical Activity Annual Meeting–Healthy People, Healthy Planet,* Prague, Czech Republic, June 2019 (Oral Presentation).

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List of Abbreviations

BCT	Behaviour Change Technique
BG	Blood Glucose
BMI	Body Mass Index
BP	Blood Pressure
Co-HELP	Community Based Healthy Lifestyle Intervention Program
CONSORT	Consolidated Standards of Reporting Trials
CPM	Counts Per Minute
CVD	Cardiovascular Disease
DALYs	Disability-Adjusted Life Years
GEE	Generalised Estimating Equations
GPAQ	Global Physical Activity Questionnaire
HbA1c	Haemoglobin A1c
HDL-C	High-Density Lipoprotein-Cholesterol
HPB	Health Promotion Board
HR-QOL	Health-Related Quality of Life
IGT	Impaired Glucose Tolerance
IPAQ	International Physical Activity Questionnaire
LDL-C	Low-Density Lipoprotein-Cholesterol
MET	Metabolic Equivalent of Task
MetS	Metabolic Syndrome
MI	Motivational Interviewing
MOH	Ministry of Health
NCD	Non-Communicable Disease
PA	Physical Activity
PI	Principal Investigator
POP	Point of Purchase
QALY	Quality-Adjusted Life-Years
RC	Recreational Centre
RCT	Randomised Controlled Trial
SB	Sedentary Behaviour
SCT	Social Cognitive Theory

SEM	Socio-Ecological Model
SF	Short Form
SG	Singapore
SMESY	Seoul Metabolic Syndrome Management
SPANS	Singapore Physical Activity and Nutrition Study
SPIRIT	Standard Protocol Items: Recommendations for Intervention Trials
SPSS	Statistical Package for Social Sciences
STEPS	STEPwise approach to Surveillance
T2D	Type 2 Diabetes
TC	Total Cholesterol
TG	Triglyceride
TIDieR	Template for Intervention Description and Replication
UK	United Kingdom
US	United States
VPANS	Vietnam Physical Activity and Nutrition Study
WC	Waist Circumference
WHO	World Health Organization
WHR	Waist-Hip Ratio

Glossary

Acceleration	Rate of change in velocity over a given time (Hills, Mokhtar, & Byrne, 2014).
Accelerometers	Small motion sensors that are sensitive to changes in body acceleration in one or all three axes. They provide objective measures (frequency, intensity and duration) related to the physical activity performed (Hansen, Kolle, Dyrstad, Holme, & Anderssen, 2012).
Aerobic activity	Any activity in which large body muscles move rhythmically for a sustained period of at least ten minutes such as brisk walking, swimming or dancing (Health Promotion Board, 2015a).
Behaviour change technique	An observable and replicable component of intervention design to induce a desirable targeted behaviour such as goal-setting and self-monitoring (Michie et al., 2015).
Disability-adjusted life-years	Years of healthy life lost to premature death and disability. It refers to the sum of years of life lost and years lived with disability (Epidemiology & Disease Control Division, 2019).
Doubly labelled water	A costly 'gold standard' method to measure total energy expenditure through the measurement of carbon dioxide production by observing the rates of elimination of a bolus dose of isotope tracers, ^{2}H (heavy hydrogen) and ^{18}O (heavy oxygen) (Westerterp, 2017).
Epoch	A digital acceleration signal produces by an accelerometer over a user-specified time period (Gabriel et al., 2010).

Haemoglobin A1c	Refers to ‘glycated’ haemoglobin and develops when haemoglobin, a protein within red blood cells that carries oxygen throughout the body, joins with glucose in the blood, becoming 'glycated'. Measuring glycated haemoglobin provides an indicator of long-term glycemic control and reflects the cumulative glycaemic history of the preceding 2–3 months (Sherwani, Khan, Ekhzaimy, Masood, & Sakharkar, 2016).
Impaired glucose tolerance	The condition of pre-diabetes or fasting blood glucose of 7 mmol/L (Ministry of Health, 2014b).
Insufficient physical activity	Not engaging in a combination of moderate and/or vigorous-intensity physical activity (Ministry of Health, 2011a).
Metabolic equivalent of task	Relates to the energy cost of sitting quietly and is equivalent to a caloric consumption of one kcal/kg/hour (Strath et al., 2013).
Metabolic syndrome	A syndrome comprising central obesity, dyslipoproteinemia (hypertension, glucose intolerance, increased triglycerides and reduced high-density lipoprotein-cholesterol), which increases an individual’s risk for type 2 diabetes and cardiovascular diseases (Yamaoka & Tango, 2012).
Moderate-intensity physical activity	Any combination of moderate-intensity activities such as walking, achieving at least 600 metabolic equivalent of task-minutes per week (Ministry of Health, 2011a).

Motivational interviewing	A technique that aids in overcoming ambivalence and motivating behaviour change (Rollnick, Butler, Kinnersley, Gregory, & Mash, 2010).
Muscle-strengthening activity	Any activity that increases skeletal muscle strength, power endurance and mass such as strength training, resistance training and endurance exercises (Health Promotion Board, 2015a).
Pedometer	A small, low-cost device attached to the hip or waist to count steps (Tudor-Locke, Bassett, Shipe, & McClain, 2011).
Physical activity	Any movement generated by the contraction of skeletal muscles that raises energy expenditure above the resting metabolic rate. It is characterised by its frequency, intensity, duration and context of practice (Caspersen, Powell, & Christenson, 1985).
Qigong	An ancient Chinese exercise that coordinates breathing, body movement and meditation (Ray, 2017).
Quality-adjusted life-years	A measure of cost-effectiveness and expressed as the ratio of dollars expended to health outcome obtained (Goldstein, 2016).
Regular exercise	Participation in any form of sports or exercise for at least 20 minutes per occasion and three or more days per week (Ministry of Health, 2011a).
Sedentary behaviour	Any waking behaviour characterised by an energy expenditure of at least 1.5 metabolic equivalent of task while in a sitting, reclining or lying posture (Tremblay et al., 2017).
Taichi	A gentle meditative mind-body exercise that assists in balance function and strength (Du et al., 2015).

Vigorous-intensity physical activity	Vigorous-intensity physical activities such as jogging and skipping from three to seven days, achieving a minimum of at least 1,500-3,000 metabolic equivalent of task-minutes per week (Ministry of Health, 2011a).
Years-of-Life-Lost	Years of life lost due to premature mortality (Epidemiology & Disease Control Division, 2019).

Chapter 1
Introduction

1.1 Background

Singapore (SG), a small, densely populated nation with 5.6 million residents and a territory of 719 km^2, faces major health challenges because of its rapidly ageing and urbanising population (Singapore Department of Statistics [SDOS], 2019). The country is ranked as the 8th healthiest nation among 169 countries globally due to favourable factors ranging from life expectancy to air quality (World Economic Forum, 2019). This ranking reflects the efforts of the Ministry of Health (MOH) in promoting good health and reducing illness through establishing partnerships with community sectors and healthcare providers to build a healthy republic (Ministry Of Health [MOH], 2019a).

The Health Promotion Board (HPB) is a government organisation under the MOH of SG, which is committed to developing and implementing national health promotion and disease prevention campaigns (Health Promotion Board [HPB], 2019a). Established in 2001, HPB provides evidence-based knowledge, formulates policies and implements public programs to promote the nation's health (HPB, 2019a). A Healthy 365 mobile app was developed by HPB in 2015 to promote PA classes at community facilities, low-calorie meals at eateries and products with the healthier choice symbols at supermarkets in incentivising the nation to sustain healthy behavioural changes (HPB, 2019b). HPB's initiatives are multifaceted and conducted across various age groups (children, adult and seniors) in different settings (community, school and workplace). These programs are aimed at empowering Singaporeans with the skills to take ownership of their health and make healthy living easily accessible to all residents (HPB, 2019b).

1.2 Statement of the problem

Despite considerable efforts to foster healthier communities through public health initiatives by HPB over the past two decades, older Singaporean adults are spending more years in poor health (MOH, 2014a). The leading and rising causes of adult mortality and disability are cardiovascular disease (CVD) and cancer (40%),

followed by type 2 diabetes (T2D) (12%) (MOH, 2014a). These major chronic non-communicable diseases (NCDs) are responsible for 64% of disease mortality rates and 32% of disease morbidity (Epidemiology & Disease Control Division [EDCD], 2019). Moreover, SG has the second-highest proportion of diabetics (12%) among developed nations (International Diabetes Federation, 2015). It is projected that the diabetic population in SG will double from 7.3% in 1990 to 15% in 2050, demanding more targeted health promotion programs and higher healthcare costs (Phan et al., 2014). Currently, T2D costs the country about SG$1 billion annually with an estimated healthcare expenditure rising to SG$1.8 billion by 2050 (National University of Singapore, 2016). These substantial economic costs are largely attributed to low levels of physical activity (PA) and unhealthy dietary practices among older Singaporeans, especially women (MOH, 2011a).

1.3 Target group

The evidence from national health surveys has suggested that the government should give priority to promoting the health of Singaporean women aged ≥50 years old. As compared to men, women aged 50–69 years exhibited more metabolic and behavioural risk factors for NCDs (MOH, 2011a). These risk factors include higher levels of:

- abdominal fat (waist-hip ratio [WHR] >0.85 for women and >1 for men [54% versus 9% in men])
- total cholesterol ([TC] >6.2 mmol/l [27% versus 21% in men])
- obesity levels (body mass index [BMI] >25 kg/m^2 [11% versus 8% in men])

In addition, they have lower levels of desirable high-density cholesterol [HDL-C] <1 mmol/l (5% versus 10% in men).

A larger proportion of these women aged 50–69 years have higher levels of leisure-time physical inactivity (no participation in any form of sports or exercise that lasted for ≥20 minutes per occasion) (72% versus 53% in men) (MOH, 2011a). They also displayed lower levels of regular PA (participation in any form of sports or exercise for ≥20 minutes per occasion, for three or more days per week) (16% versus 28% in males). A lower overall health status of ‘very good’ and ‘good’ (55% versus 61% in men) was reported by these women (MOH, 2011a).

Compared to men, less than half of these women aged 50–69 years met the recommended serving guidelines for fruit (34% versus 30% in men), vegetables (26% versus 27% in men) and wholegrains (43% versus 21% in men) (HPB, 2013). On the other hand, more than half of these women exceeded 100% of the recommended dietary allowance for saturated fat intake (67% versus 61% in men), salt intake (75% versus 87% in men) and added sugar as a sweetening agent to their beverages (55 versus 64% in men) (HPB, 2013). Provision of primary prevention interventions at conveniently located recreational centres (RCs) may support and empower these older women in the adoption of healthy lifestyle practices within their communities. These at risk women form a key target group to determine the effectiveness of interventions to improve health behaviours and health outcomes in the RC settings.

1.4 Study setting

The majority of Singaporean families (80%) reside in high-rise, public housing (Koh, Leow, & Wong, 2015). Unique to SG, RCs are built on the void decks of housing estates to promote caring neighbours, racial integration and friendship among residents (People's Association, 2019). These centres are managed by the RC managers and volunteers who work with government agencies to organise cultural, educational and wellness activities for residents. The facilities and activities of these centres are constantly upgraded to cater to the residents' lifestyles and interests. Most patrons (78%) who frequent these centres in proximity to their homes are women aged ≥50 years old (TSAO Foundation, 2011), providing a desirable community hub to shape their PA and dietary behaviours.

1.5 Study rationale

Due to the rising incidence of NCDs worldwide, the World Health Organization (WHO) has strongly emphasised modifiable risk factors such as regular PA levels and nutritious diets as key cornerstones for the prevention and management of NCDs (World Health Organisation [WHO], 2017a). In SG, policymakers and researchers are urged to develop effective PA and dietary behavioural change interventions to tackle the rising incidence of NCDs, particularly T2D (Ang et al., 2019). Moreover, the RCs are highly promoted as recreational venues with a high demand for them to support healthy ageing, the characteristics of these venues in supporting positive

behaviour changes and improving health outcomes for the targeted at risk group are still poorly understood (Wong, Lee, James, & Jancey, 2019). Studies of such interventions can provide insights into the interaction between optimal resources, program ambassadors, delivery strategies and adequacy of facilities and activities to support PA and healthy dietary practices among neighbourhood residents.

Physical activity and dietary behaviour change interventions are effective in improving PA levels and healthy eating habits to reduce the incidence of NCDs in community settings. Various systematic reviews and meta-analyses have revealed significant improvements in BP, anthropometric measurements (weight, BMI, WHR, body fat percentage, waist circumference [WC]), lipid (TC, HDL-C, low-density lipoprotein-cholesterol [LDL-C] and triglyceride [TG]) and glycaemic profile, in PA and dietary behavioural studies investigating health outcomes (Borek, Abraham, Greaves, & Tarrant, 2018; Howells, Musaddaq, McKay, & Majeed, 2016; Zhang et al., 2017). However, PA and dietary interventions were based mainly on research among non-Asian populations (Chapman, Qureshi, & Kai, 2013; Muilwijk et al., 2018; Yamaoka & Tango, 2012). It is worth reiterating that the paucity and poor quality of existing Asian PA and dietary intervention research make their findings inconclusive and inapplicable in the Singaporean context. Therefore, more exploration in the development, implementation and evaluation of a culturally appropriate PA and nutrition intervention could support positive behavioural changes and improve metabolic risk factors of chronic diseases among community dwelling Singaporean women.

1.6 Research aim and objectives

The SPANS aimed to develop, implement and evaluate a six-month community-based PA and nutrition behavioural cluster randomised controlled trial (RCT) for Singaporean women aged ≥50 years old attending RCs.

To achieve the above aim, this study's objectives were to:

1. Design and implement a six-month cluster RCT of a community-based intervention to improve PA and dietary behaviours of Singaporean women aged ≥50 years old attending RCs (see **Publication 1**, Appendix B).

2. Examine the facilities and activities of RCs to support PA and dietary practices for the target group (see **Publication 2**, Appendix B).

3. Evaluate the appropriateness and acceptability of the intervention strategies and resources for the target group (see **Publication 3**, Appendix B).

4. Assess changes in PA, sedentary and dietary behaviours of the intervention group participants relative to the control group participants from pre- to post-test (see **Publication 4**, Appendix B).

5. Assess changes in BP, anthropometric measurements, fasting BG and lipid profiles and HR-QOL indicators of the intervention group participants relative to the control group participants from pre- to post-test (see **Publication 4**, Appendix B).

It was hypothesised that, after the six-month study, intervention group participants compared to control group participants, would display a statistically significant improvement in the following outcome measures:

Primary Outcome Measures:

- Self-reported PA behaviours (moderate, vigorous, total and walking and cycling) and sedentary behaviour (sitting time).
- Objective measures of PA level (moderate, vigorous and total) and sedentary behaviour (sitting time).
- Self-reported dietary behaviours (intake of fruit, vegetables, wholegrains, salt and salty sauces, fatty foods and sugary beverages).
- Fasting blood glucose and lipid profile (TC, LDL-C, HDL-C, non-HDL- C, TG and cholesterol ratio).

Secondary Outcome Measures:

- Anthropometric measurements (weight, BMI, hip circumference [HC], WC, WHR and body fat percentage).
- Systolic and diastolic BP.
- Self-reported health-related quality of life indicators.

1.7 Significance of the research

Building upon previous PA and nutrition research (Blackford et al., 2017; Burke, Jancey, Howat, Lee, & Shilton, 2013; Jancey et al., 2018; Tran, Jancey, et al., 2017), this study is the first cluster RCT of a community-based PA and dietary behavioural change intervention targeting Singaporean women aged ≥50 years old who attend RCs. The SPANS explored the interplay of factors influencing health behaviours and outcomes when developing, implementing and evaluating the intervention in an Asian setting, making it an original contribution and expansion of existing knowledge in the field of public health. The significance of this study includes the following:

1. Despite the government's past efforts to reduce chronic diseases and mobilise resources to promote PA and healthy eating opportunities, NCDs are still increasing among older Singaporean women (MOH, 2014a). To address this challenge, the SPANS actively engaged the target group in giving continual feedback and improvements to develop a timely baseline primary prevention intervention. The findings are potentially applicable for chronic disease prevention in Singapore.

2. The study's target group is women aged ≥50 years old who are regular patrons at RCs located close to their homes (Wong et al., 2019). These centres provide unique, natural monitoring of the health-promoting environment to encourage the target group in modifying their health practices. Exploration of socio-environmental determinants at the RCs can contribute to the effectiveness of the intervention in supporting healthy behaviours.

3. Singapore is one of the world's rapidly ageing countries (Malhotra et al., 2019; SDOS, 2018a). Given its rising chronic conditions, the demand for culturally appropriate interventions offers an opportunity to trial behavioural change strategies to accommodate the growth of an ageing population. These strategies can provide valuable information on relevant participants' motivators, barriers and suggestions over time to promote behavioural changes and consequently reduce risk factors of NCDs.

4. The refinement of the SPANS can guide the development of future PA and dietary behavioural interventions. Such initiatives can be replicated in primary care settings such as senior activity centres and day care facilities at the void deck of public housing precincts in Singapore. This approach may increase the outreach and benefit a larger segment of at risk older communities.

1.8 Outline of the thesis

This thesis consists of six chapters including 1) Introduction, 2) Literature review, 3) Methodology (with one publication), 4) Results (with three publications), 5) Discussion and 6) Conclusion and recommendations.

Chapter 1 begins with background information on the research study. It provides a brief overview of the study location and setting and issues relating to the rising behavioural and metabolic risk factors of NCDs in Singaporean women aged ≥50 years old. It outlines the rationale, aim and objectives and the significance of positive PA and dietary behaviours to address the incidence of chronic diseases.

Chapter 2 presents a literature review on metabolic and behavioural risk factors of NCDs and the use of PA and dietary behavioural change interventions for older adults to tackle the NCD pandemic worldwide and in Asia. It examines studies on the theories, process evaluation and the built and social environment that informs the development of the study.

Chapter 3 describes the study's methodology, which includes the intervention design, procedure, theoretical framework, formative evaluation, intervention

program, data management plan, outcome measures and process evaluation. It elaborates on the published protocol paper (see **Appendix B**, *Publication 1*):

- **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: Study protocol for a randomised controlled trial. *Trials,* 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

Chapter 4 reports on the research findings of the SPANS. The results are also presented in the following three published papers (see **Appendix B**, *Publications 2-4*):

- **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore. *International Journal of Environmental Research and Public Health,* 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343
- **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process evaluation of the 'Singapore Physical Activity and Nutrition Study'. *Evaluation and Program Planning,* 83, 101847. http://doi:https://doi.org/10.1016/j.evalprogplan.2020.101847
- **Wong, E.Y.-S**., James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: A cluster randomised controlled trial. *Asia Pacific Journal of Public Health*. https://doi.org/10.1177/1010539520977311

Chapter 5 examines the study's results and discusses the implications of the findings in relation to the research literature on PA and dietary behavioural interventions. Strengths and limitations are highlighted in this chapter.

Chapter 6 summarises the study's conclusions and suggests recommendations for future research based on the literature review and the study's findings.

Chapter 2

Literature Review

2.1 Introduction

Physical inactivity and poor diet have led to an escalation of major non-communicable disease (NCDs), primarily cardiovascular disease (CVD), cancer and type 2 diabetes (T2D) (WHO, 2019a). In addition, the emergence of these diseases has been widely documented as a global pandemic impacted by urbanisation, socio-economic transition and ageing populations. Because of rapidly ageing communities and the higher prevalence of NCDs in older adults, the World Health Organisation (WHO) has prioritised adults aged ≥50 years old as a prime target group for NCD prevention (Yiengprugsawan, Healy, & Kendig, 2016). The solution to this pandemic may involve, in part, greater engagement of older adults in physical activity (PA) and dietary behavioural change interventions to reduce their risk of developing NCDs.

Singapore's (SG) Health Promotion Board (HPB), governed by the Ministry of Health, was set up in 2001 to develop health promotion programs to mitigate NCDs (Toh, Chew, & Tan, 2002). In SG, participants engaging in the seasonal 'National Step Challenge' to increase their step counts were provided with complimentary Fitbits by the HPB (Yao et al., 2019). The HPB organised the 'Eat, Drink and Shop Challenge' to encourage Singaporeans to shop for healthier choice products and select low-calorie meals at healthy eateries (HPB, 2019b). Participants were awarded health points on both challenges via a Healthy 365 mobile app. Despite immersive efforts in investing heavily in such programs as the 'National Steps Challenge' and 'Eat, Drink and Shop Healthy Challenge' to curb the increasing NCDs, HPB still faces a growing disease burden accompanied by an ageing population (EDCD, 2019; HPB, 2019b). Findings of the latest national health surveys displayed an increasing trend in behavioural (e.g., low PA levels and poor diet) and metabolic (e.g., T2D) risk factors of NCDs in Singaporean adults (HPB, 2018; MOH, 2018). Moreover, published research that measures the impact of HPB's PA and dietary campaigns is limited, and few researchers have assessed the effectiveness of PA and dietary interventions on behaviour and health outcomes in Asia. Therefore, the efficacy of behavioural modification interventions is warranted in future studies, particularly in older Singaporean adults.

Singaporean women are at risk of NCDs because of their low PA levels and poor eating habits, making them an ideal target group for behavioural change interventions. These women aged ≥50 years old form a priority group for NCD prevention because they exhibit increasing metabolic risk factors of chronic diseases such as raised blood pressure (BP) and cholesterol than in their male counterparts (HPB, 2013; MOH, 2011a; Wu & Chan, 2011). Furthermore, a nationwide 2013 survey confirmed low PA levels among Singaporean female respondents who participated in the survey (Win et al., 2015). Reasons cited for their low PA levels included their busy role in household management and grandparenting, perceived adequate PA from housework chores and lack of awareness about government PA initiatives (Bu & Chung, 2018; MOH, 2011a). Moreover, women aged ≥40 years old have a high frequency of eating out (77%) at Singapore eateries that serve energy-dense, nutrient-poor meals associated with increased abdominal obesity, CVD and T2D in these women (Naidoo et al., 2017). Due to the women's competing lifestyle priorities and unhealthy PA and dietary practices, they should be targeted to lower their susceptibility to chronic diseases.

When conducting programs with these older women, the socio-environmental factors of the setting should be considered to foster positive behaviour (WHO, 2019a). For instance, government support and neighbourhood networks, supporting infrastructure and safety features of the setting, may influence the engagement of the target group in PA or dietary sessions (Probst-Hensch, Tanner, Kessler, Burri, & Künzli, 2011). The ubiquitous recreational centres (RCs) are highly accessible, government-supported venues for conducting such programs (Wong et al., 2019). These RCs have been preferred by older Singaporean women to participate in neighbourhood programs that facilitate their healthy eating and physically active practices (Duke-National University of Singapore, 2019). Appropriate community activities within such premises are paramount to manage the needs and demands of ageing dwellers (Kremers, Eves, & Andersen, 2012). Furthermore, the infrastructures and programs of RCs should be periodically reviewed to remain innovative and keep abreast of emerging trends catering to women's preferences and interests. Taking into account the built and social aspects of the RCs may optimise program adherence and positively shape their PA and dietary patterns.

In summary, community-based interventions at the neighbourhood RCs are urgently required to mitigate the burden of chronic diseases in older Singaporean women. This research aims to determine whether PA and dietary behaviour change interventions are effective in improving behavioural and metabolic risk factors of NCDs in Singaporean women aged ≥50 years old.

2.2 Non-communicable diseases

2.2.1 Disease mortality and burden

Worldwide

Non-communicable diseases are non-infectious and non-transmissible medical conditions (Kim & Oh, 2013). However, they are progressive chronic conditions affected by genetic, physiological, environmental and behavioural factors (WHO, 2019a). Chronic diseases are recognised as the 'diseases of the 21st century' (World Bank, 2016), which have been responsible for 41 million deaths annually worldwide (71% of all deaths) (WHO, 2019a). Principal causes of global mortality include CVDs (17.9 million, 31% of all deaths), followed by cancer (9 million, 6% of all deaths) and T2D (1.6 million, 3% of all deaths) (WHO, 2018a). The highest death rates (45% globally) were observed in the over-50-year-old age group (WHO, 2018b), especially in women, making them a key target group for NCD programs (Peters, Woodward, Jha, Kennedy, & Norton, 2016). Such programs should be carefully crafted to suit at risk older women (The Lancet, 2017) to empower them to take ownership and support their motivation to address NCDs. Consequently, targeted PA and dietary interventions for older women might reduce their NCD mortality rates.

Singapore

Mortality rates of NCDs (cancer, CVD and T2D) formed 64% of the years-of-life-lost due to premature mortality in 2017 (EDCD, 2019). Moreover, these NCDs have been responsible for 32% of the disability-adjusted-life-years (DALYs)—years of healthy life lost to premature death and disability (EDCD, 2019). T2D, one of the major NCDs, is projected to affect one million Singaporeans by 2050 (MOH, 2019b). Furthermore, the percentage of Singaporean adults aged ≥50 years old has increased by 46% from 2000 to 2019 (SDOS, 2018a), and more than two-thirds of them suffer from at least one NCD condition as the population ages (Duke NUS Medical School,

2017). Dans et al. (2011) recommended that the government partner with community sectors to create conducive environments for primary prevention interventions. Pelliccia et al. (2015) also reinforced that global policies should encourage integrated action between stakeholders to target PA and dietary behavioural change interventions in combatting NCDs. For the long term sustainability of PA and dietary interventions to deal with the accelerating NCD mortality and morbidity, relevant stakeholders should be engaged to identify best practices for disease prevention.

2.2.2 Economical cost of non-communicable diseases

The global economic cost of NCD mortality and morbidity was projected to reach United States (US) $13 trillion annually by 2030 (Atun et al., 2013). Three-quarters of these costs will result from deaths of adults aged ≥60 years old (Bloom, 2011). Similarly, the Singapore government invests heavily in a projected expenditure of US$8 billion for CVDs (Economist Intelligence Unit, 2018) and US$1 billion for T2D by 2050 (Khalik, 2017). To mitigate the high cost of NCDs, addressing physical inactivity and poor diet remain plausible strategies for chronic disease prevention.

Physical inactivity

Physically inactive populations include individuals who fail to meet their weekly moderate to vigorous PA guidelines (Tremblay et al., 2017). Physical inactivity is the leading cause of disease burden for CVD (30%), T2D (27%) and cancer (23%) (WHO, 2010a). It accounted for 1.6 million deaths yearly (Forouzanfar et al., 2016) and was the fourth-highest global mortality risk factor (besides hypertension, tobacco use and hyperglycaemia) (Lee et al., 2012). Furthermore, physical inactivity cost US$54 billion internationally for NCDs and was responsible for 13.4 million DALYs worldwide for 142 countries (93% of the world's population) in 2013 (Ding et al., 2016). Physical inactivity was higher in older women (aged ≥60 years old) than men, as revealed by PA surveillance data from 122 high-income countries (Hallal et al., 2012), making them ideal for targeted PA intervention to prevent NCDs.

Poor diet

High salt and low wholegrains and fruit consumption have attributed to diet-related NCD deaths (8 million) and DALYs (217 million) globally (Afshin et al., 2019). Moreover, the cost of unhealthy diets on NCDs has ranged in average cost per capita

from China (US$4) and Australia (US$70) to Europe (US$172) (Candari, Cylus, & Nolte, 2019). The Global Burden of Disease Study in 2017 has confirmed that an optimal diet could prevent 1 in every 5 deaths in 195 countries, regardless of age, gender and socio-demographic development of a country (Afshin et al., 2019). Such results should be interpreted with caution because they were observational studies with variation in dietary measures and based mainly on Western populations, making the findings less generalisable (Afshin et al., 2019).

2.2.3 Addressing the cost of non-communicable diseases

Physical activity and dietary interventions are cost-effective investments in the prevention of NCDs. The cost-effectiveness ratio represents the amount of additional health obtained for each additional cost spent on a health program and is expressed as dollars per quality-adjusted life-years (QALYs) (Goldstein, 2016). To illustrate, a cost-effectiveness ratio of US$10,000 per life-year gain for a program will equate to one more life-year gain for each additional US$10,000 spent on the program. Policymakers globally use analysis of these ratios to compare the effectiveness of interventions and make decisions about resource allocation (Dubois, 2015). One way to determine if an intervention is worthy of reimbursement is to determine if the cost-effectiveness ratio falls below the threshold of US$50,000 per life-year gain set by the American College of Cardiology and the American Heart Association or US$37,500 per life-year gain set by the National Institute for Health and Clinical Excellence in the United Kingdom (UK) (Dubois, 2015).

In a review of nine pre-diabetes intervention studies in the US, UK and Sweden, a cost of US$1300 per QALYs was projected over a lifelong time horizon but this cost increased to US$33,000 per QALYs when conducted for 3 years (Glechner et al., 2018). These findings are in line with a Swedish cost analysis study on PA and dietary intervention for metabolic syndrome (MetS) (Saha et al., 2013) that affirms longer periods of investment in intervention result in greater cost-savings with a lower cost per QALY. A simulated model of a 25-year PA and dietary study in the US delayed 885,000 T2D cases and saved US$5.7 billion (Zhuo et al., 2012). Such findings justify the idea that policymakers should fund interventions over a longer time frame. Other feasible PA and dietary interventions included a pre-diabetic Swedish initiative over a lifelong time horizon with a cost of US$7627 per QALY

(Neumann et al., 2017), three-year counselling randomised controlled trial (RCT) for Swedish adults at moderate-to-high risk of CVD at US$3241 per QALY gain (Eriksson et al., 2010) and a 12-week community-based health program for US adults (aged >45 years) at US$1413 per QALY gain (Akanni, Smith, & Ory, 2017). However, these cost-effective ratios are estimates based on assumptions and may be prone to errors. Since these interventions differ in duration, context and outcomes across diverse populations, future research should engage economists in validating these ratios and work with policymakers to determine if these beneficial effects remain over time and justify appropriate interventions. Critically, the cost-effectiveness analysis in many studies recommends funding long-term PA and dietary interventions to gain optimal economic and health benefits.

2.3 Metabolic risk factors of non-communicable diseases

Hypertension, hyperglycaemia, overweight and obesity and hyperlipidaemia are metabolic risk factors that trigger physiological changes and increase the risk of NCDs (WHO, 2019a). Hypertension is the greatest contributor to the global burden of chronic diseases, followed by hyperglycaemia, overweight and obesity and dyslipidaemia (Forouzanfar et al., 2016). A systematic review of 106 Western and Asian studies showed that these four risk factors exist in combination with one another (American Diabetes Association, 2016; Bragg et al., 2016; Park et al., 2013; Sarwar et al., 2010) and are inversely related to regular PA and healthy diets (WHO, 2020a). This section outlines PA and/or dietary interventions targeted at older adults to improve metabolic risk factors of NCDs.

2.3.1 Hypertension

Hypertension, a major metabolic risk factor of CVDs, is defined as systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg (WHO, 2013a). For Singaporean adults aged ≥80 years old, the cut-off value for systolic BP is ≥150 mm Hg while diastolic BP remains as ≥90 mm Hg (MOH, 2017). Hypertension increases with age and is strongly associated with the burden of CVD (WHO, 2013a). In 67 RCTs of ≥3 months (Asia, n = 4), high intake of fruit, vegetables and wholegrains and low intake of salt was the most effective dietary approach to reduce mean BP in pre-hypertensive and hypertensive adults (mean age 47 years) compared to other diets (e.g., low-fat diet) (Schwingshackl et al., 2018). Another review of hypertensive

adults (mean age 57 years) in nine countries (including Taiwan, Japan and India) revealed that a six-month PA RCT decreased mean systolic and diastolic BP (by 4–8 mmHg) (Semlitsch et al., 2013). The authors commented that the small sample size (n = 20) and non-reporting of medications may have biased the results. PA and dietary RCTs with larger sample sizes (n = 70–49,000 adults, mean age 49 years) (including a Japanese study) showed that PA and dietary counselling of longer duration (6–12 months) conferred a higher reduction in BP in participants without CVD risk factors (Patnode, Evans, Senger, Redmond, & Lin, 2017). Although a vast amount of literature has shown the effectiveness of such interventions in reducing hypertension, more evidence from well-designed studies on Asian populations is yet to be conducted.

2.3.2 Hyperglycaemia

Hyperglycaemia is the condition of excessive blood glucose (BG) levels >7.8 mmol/L (Umpierrez et al., 2012) caused by insulin resistance and excessive glucose production (Sharabi, Tavares, Rines, & Puigserver, 2015). Reduced functional capacity of insulin in older adults puts them at risk of hyperglycaemia that leads to T2D (Lee & Halter, 2017). The risk of T2D has been shown to be reduced through the consumption of a Mediterranean diet, comprising a high intake of fruit, vegetables and wholegrains and moderate consumption of fish and olive oil (Schulze, Martínez-González, Fung, Lichtenstein, & Forouhi, 2018). A review of studies >3 months by Schwingshackl et al. (2018), found that healthy adults (mean age 49 years) adhering to a Mediterranean diet, significantly reduced their risk of becoming diabetic (19%). Such diet also resulted in statistically significant reductions in fasting BG levels compared to low-fat diets in overweight, diabetic patients over 12 months (Mancini, Filion, Atallah, & Eisenberg, 2016). Reductions in T2D incidence for pre-diabetic adults (fasting BG ≥7 mmol/L) and T2D adults (mean age 65 years) were also documented in 11 PA and dietary RCTs conducted for ≥6 months (Schellenberg, Dryden, Vandermeer, Ha, & Korownyk, 2013). In another review of PA and dietary interventions (in the US, Europe, China and India) of >2 years duration, adults with impaired glucose tolerance (IGT) (fasting BG = 7 mmol/L) who achieved their dietary goals and greater weight loss displayed a reduction in their progression to T2D (Gillett et al., 2012).

2.3.3 Overweight and obesity

Overweight or obesity is the excess accumulation of weight and body fat that increases the risk of hypertension, hyperglycaemia and dyslipidaemia (Gadde, Martin, Berthoud, & Heymsfield, 2018). Improvements in weight loss among older adults have been evident in a plethora of PA and dietary behavioural modification programs. A meta-analysis of 22 T2D prevention programs (in the US, Australia, Europe and Japan) conducted for ≥12 months with 5500 overweight and obese adults (mean age 52 years, mean BMI 31 kg/m^2) reported statistically significant weight loss (−2.3 kg) only in the intervention groups at the 12-month follow-up (Dunkley et al., 2014). However, there is a need to explore the challenges in motivating older adults to sustain long-term positive PA and dietary behaviours.

Measures of overweight and obesity

Body mass index (BMI), waist circumference (WC) and waist-hip ratio (WHR) measurements are used to assess an adult's weight-related risk for NCDs. BMI cut-off values for Asians are 18.5 (underweight), 23–27.4 (overweight) and ≥27.5 (obese) (HPB, 2016). Compared to Europeans of identical BMI, Asians have a higher percentage of body fat (3%–5%), which increases their risk for NCDs (Boffetta et al., 2011). WC is a measure of abdominal obesity (Liu, Tong, Tong, Lu, & Qin, 2011) and the cut-off values for WC (>90 cm for men, >80 cm for women) are adopted by Asian populations (Malaysia, China, Singapore, Taiwan and Korea) for detection of overweight and obesity (Ahmad, Adam, Nawi, Hassan, & Ghazi, 2016; Cheng et al., 2010; Fauziana et al., 2016; Liu et al., 2011; Yoon & Oh, 2014). WHR is an indicator of central adiposity associated with an increased risk of CVD (Pimenta et al., 2016; Shuster, Patlas, Pinthus, & Mourtzakis, 2012) and T2D (Cheng et al., 2010; Mogre, Abedandi, & Salifu, 2014; Xin et al., 2012). A high WHR in overweight and obese Singaporean adults aged ≥60 years old was correlated with hypertension, CVD and T2D (Fauziana et al., 2016). Chan and Woo (2010) also supported the use of BMI, WC and WHR as suitable screening methods for obesity and overweight.

Cost of overweight and obesity

Over 39% of the world's population (1.9 billion adults aged ≥18 years old) was overweight in 2016 (WHO, 2020b). Among this population, 13% or 650 million adults were obese. The trend of overweight and obesity is projected to affect half of

the world's population by 2030 (Tremmel, Gerdtham, Nilsson, & Saha, 2017). In addition, overweight and obesity cost US$2 trillion in 2014 and increased NCD mortality and morbidity rates on individuals, families and communities (Tremmel et al., 2017). PA and dietary modification interventions are key priority areas for reducing obesity, as advocated by various researchers in weight-related studies (Nyberg et al., 2018). Chan and Woo (2010) asserted that healthy PA and dietary practices need to be driven by highly supportive multidisciplinary professionals. Ultimately, the integration of PA and dietary strategies by psychologists, data scientists, public health experts and economists are emergent solutions to reduce the impact of economical, psychological and physiological costs associated with overweight and obesity.

2.3.4 Dyslipidaemia

Dyslipidaemia is elevated total cholesterol (TC), triglyceride (TG) and low-density lipoprotein-cholesterol (LDL-C) with low levels of high-density lipoprotein-cholesterol (HDL-C) in the bloodstream (Mancini, Hegele, & Leiter, 2018). Dyslipidaemia appears to be a major contributing risk factor of NCDs. For instance, a 20-year study of 26,000 non-diabetic American women (mean age 53 years) documented dyslipidaemia as being associated with insulin resistance (Harada et al., 2017). Furthermore, it is also a risk factor for CVD as found in 137,000 urbanised, overweight Chinese women aged ≥40 years old (Opoku et al., 2019). However, Zhang et al. (2017) displayed a statistically significant improvement in TG (−0.07 mmol/L), LDL-C (−0.08 mmol/L) and HDL-C (+0.03 mmol/L) in the adults with IGT in a review of 79 PA and dietary RCTs lasting ≥12 months. Moreover, another 49 PA and dietary RCTs (n = 74) of ≥12 months duration with US adults (mean age 56 years) at risk of CVD by Lin et al. (2014), reported statistically significant improvements in mean TC levels (-0.12 mmol/L) and mean LDL-C levels (−0.09 mmol/L). Collectively, investing in PA and dietary interventions are of importance in managing dyslipidaemia across diverse populations of older adults.

2.4 Behavioural risk factors of non-communicable diseases

Physical activity, sedentary behaviour (SB) and diet are highly modifiable behavioural risk factors that can prevent chronic diseases among at risk older adults (WHO, 2019a). Understanding the benefits, recommendations and measurements of these risk factors can assist in determining strategies to tackle the metabolic risk factors of NCDs.

2.4.1 Physical activity

Benefits

Physical activity is "the movement produced by the contraction of skeletal muscles that expends energy, characterised by its frequency, intensity and duration performed during work, leisure and daily commute" (Caspersen et al., 1985, p. 126). It is widely acknowledged for its physiological, psychological and functional effects on the health of older adults. Warburton and Bredin (2017) showed an inverse relationship between increasedPA and reduced mortality for 25 chronic conditions and highlighted that this benefit can be achieved by doing only 50% of the recommended PA guidelines (75 minutes per week of moderate-intensity PA). A 13-year cohort study by Wen et al. (2011) also reported a 14% lowered risk of CVD mortality in 416,000 Taiwanese adults (41% were ≥60 years old) with or at risk of NCDs who performed 90 minutes weekly of moderate-intensity PA compared to those adults with no PA. Moreover, PA played an integral role in reducing obesity-related NCDs (Chan, 2019), especially when doing aerobic PA (Swift, Johannsen, Lavie, Earnest, & Church, 2014). Also, physically active older adults experienced less depression, anxiety and bodily pain (Abdelbasset, Alsubaie, Tantawy, Elyazed, & Elshehawy, 2019; Halaweh, Willen, Grimby-Ekman, & Svantesson, 2015). Lastly, the functional mobility of older adults has improved with muscle-strengthening activities (Taylor, 2014), leading to better balance and coordination with a lower risk of falls (Franco, Pereira, & Ferreira, 2014; Gillespie et al., 2012). Recognising the many advantages of PA, policymakers have adopted WHO's recommended guidelines worldwide to promote physically active nations for NCD prevention.

Recommendations for physical activity

The WHO has established global PA recommendations to inform national policies and population-based interventions (WHO, 2010, 2018c). In general, adults aged ≥18 years old are encouraged to do 150 minutes per week of moderate-intensity aerobic PA, or 75 minutes per week of vigorous-intensity aerobic PA, or a combination of both forms of PAs (WHO, 2010). Singapore's PA guidelines for adults aged ≥50 years old, which have been adapted from WHO's global recommended guidelines to promote PA, are listed below (HPB, 2015a):

- Perform aerobic activity for ≥10 minutes per session and spread out throughout the week.
- Do muscle-strengthening activities such as hand-held weights, resistance bands and carrying groceries twice a week.
- Conduct mind-body exercises such as qigong, taichi, yoga and pilates twice a week.
- Practise other forms of PA daily such as:
- Walk instead of commuting or driving.
- Get off at one or more bus or train stops earlier or park the car further away to walk to a destination.
- Individuals with limitations, disabilities or chronic conditions should follow their doctor's advice on suitable PA for them.

These specific guidelines impart key PA messages and serve as benchmarks to measure and monitor whether Singaporeans are meeting them. Indeed, the promotion of population-specific PA guidelines is deemed essential for NCD prevention.

Measures of physical activity

Physical activity assessment is useful for examining the relationship between PA patterns and the prevention of NCDs. Its rationale lies in monitoring PA levels against current guidelines and adjusting interventions to improve PA levels across a nation. Although many tools can be used to monitor changes in PA levels and energy expenditure (Kowalski, Rhodes, Naylor, Tuokko, & Macdonald, 2012), not all methods are realistic for population-based interventions. For example, the 'gold

standard' of PA measurement is doubly labelled water, but it requires specialised assessors, laborious observation intervals and sample analysis (Westerterp, 2017). Conversely, pedometers, accelerometers and self-report questionnaires are commonly used to measure PA in large-scale studies due to their feasibility and reasonable cost (Ferguson, Rowlands, Olds, & Maher, 2015; Lee, Kim, & Welk, 2014; Lee & Shiroma, 2014).

Objective measures

Accelerometers are the preferred instrument for PA measurements due to their advantages over pedometers. The traditional approach for recording step counts was to use an inexpensive pedometer (Tudor-Locke et al., 2011). A review of 103 PA interventions by Silfee et al. (2018) documented that more studies used pedometers (51%) compared to accelerometers (41%). However, accelerometers have gained popularity in recent decades due to their higher functional capability than pedometers. Firstly, these small sensor-based wearables have huge data storage capacity to measure PA intensity and duration (Hills et al., 2014; Lee & Shiroma, 2014). Secondly, they have quantified movement with greater precision and accuracy (Hills et al., 2014). Lastly, they have displayed higher validity and reliability for PA measurements (Butte, Ekelund, & Westerterp, 2012; Chomistek et al., 2017). However, accelerometers cannot detect activities such as resistance training, carrying loads, swimming and cycling (Hansen et al., 2012), lack proprietary algorithms to quantify PA levels and are insensitive in measuring light-intensity PA and SB (Butte et al., 2012). Despite these shortcomings, accelerometers have been widely applied to validate PA measurements with self-report questionnaires in Singaporean studies (Khaing Nang et al., 2010; Win et al., 2015).

Self-report measures

Supported by various researchers, self-report questionnaires are easy, practical and inexpensive to administer (Strath et al., 2013; Ueno, Sebastião, Corazza, & Gobbi, 2013). When combined with accelerometers, they achieve reasonably high validity and reliability in PA measurements of older adults (Inoue et al., 2011; Skender et al., 2016; Ueno et al., 2013). The more widely used questionnaires are the International PA Questionnaire (IPAQ) and the Global Physical Activity Questionnaire (GPAQ) (Van, Chinapaw, Mokkink, Van Mechelen, & Terwee, 2010). Although the short

(nine items) and long (31 items) version of the IPAQ were validated in 12 countries (Lee, Macfarlane, Lam, & Stewart, 2011) and its short form was accepted for PA surveillance across 20 countries (Bauman et al., 2009), it displayed weak correlations of ≤ 0.57 for moderate to vigorous PA and walking levels and overestimated PA levels compared to an accelerometer (Lee, Macfarlane, et al., 2011). Other drawbacks included its poor validity and accuracy in accelerometer-based measurements among adults in Singapore (Nang et al., 2011) and Hong Kong (Lee, Yu, et al., 2011). The alternative tool, GPAQ (16 items), is endorsed by the WHO as the STEPwise approach to Surveillance (STEPS) for PA behaviour globally (Stelmach, 2018). It is used in over 100 countries, including Singapore (Chu, Ng, Koh, & Müller-Riemenschneider, 2015; Win et al., 2015) to monitor PA and SB (WHO, 2019c). This tool demonstrated low-to-moderate validity and acceptable to excellent reliability in 20 countries when compared to accelerometers (Herrmann, Heumann, Der Ananian, & Ainsworth, 2013; Keating et al., 2019). Therefore, combining the GPAQ with accelerometers make them practical tools for monitoring PA patterns and evaluating nationwide PA interventions for NCD prevention.

2.4.2 Sedentary behaviour

Sedentary behaviour is characterised by "energy expenditure of ≤ 1.5 METs during sitting, reclining, lying down and screen-based entertainment" (Tremblay et al., 2017, p. 2). According to the Global Action Plan for PA by WHO (2018d) 2018–2030, such behaviour has led to high costs on metabolic risk factors of NCDs. Supporting epidemiological evidence has shown that SB in older adults is strongly linked to CVDs (Young et al., 2016), obesity (Biddle et al., 2010) and hyperglycaemia and T2D (Fritschi et al., 2015; Sardinha, Magalhães, Santos, & Júdice, 2017). Moreover, SB was also associated with NCD incidence, mortality and hospitalisation, independent of PA (Biswas et al., 2015; Dogra & Stathokostas, 2012). Furthermore, prolonged SB resulted in 69,000 deaths from CVD, T2D and cancers, accompanied by a cost of US$1 billion in a UK study from 2016–2017 (Heron, Neill, McAneney, Kee, & Tully, 2019).

Prevalence of sedentary behaviour

In a review of 23 studies from seven countries, most adults (60%) aged >60 years old reported engaging in daily sitting time >4 hours, 65% in screen-watching >3 hours and 55% in TV-screening >2 hours (Harvey, Chastin, & Skelton, 2013). In Singapore, 40% of adults, mostly women (mean age 43 years), spent six hours sitting daily, which is an independent risk factor for premature NCD mortality (Win et al., 2015). Due to the high prevalence of SB among Singaporean adults, guidelines for SB recommended breaking up sitting periods lasting >90 minutes with 5–10 minutes of movement (HPB, 2015a). Future research should investigate effective strategies to reduce SB among older adults.

Measures of sedentary behaviour

Similarly to PA measurement, self-report questionnaires and accelerometers have been used to measure SB (Atkin et al., 2012). Although questionnaires are easy to use and cost-effective (Healy et al., 2011), they have some disadvantages. Firstly, there may be inaccurate reporting of time spent in SB activities in self-report questionnaires (Prince, LeBlanc, Colley, & Saunders, 2017). Secondly, they use the television or computer screen-time as typical SBs (Ford, 2012) and other SB, such as reading or occupational and transportation-related activities may not be reported. Lastly, they underestimate SB and have lower validity compared to accelerometry (Cleland et al., 2014; Clemes, David, Zhao, Han, & Brown, 2012). On the other hand, accelerometers are precise and valid in measuring SB (Dos Santos et al., 2018; Husu et al., 2016). Therefore, questionnaires should be combined with accelerometers to improve the validity and reliability of SB research (Healy et al., 2011; Heesch, Hill, Aguilar-Farias, van Uffelen, & Pavey, 2018). Using these tools, assessment of SB is essential to monitor its patterns for designing effective interventions for sedentary populations.

2.4.3 Diet

Benefits

The role of healthy diets in reducing the risk of NCDs are evident in older adults, who are at risk of nutrition deficiency (Bruins, Van Dael, & Eggersdorfer, 2019). A wealth of research displayed strong associations between high intake of fruit, vegetables and wholegrains and low intake of salt, sugar and saturated fat and lower risk of CVD, cancer and T2D (American Institute for Cancer Research, 2018; Micha et al., 2017). Kimokoti and Millen (2016) reported that these beneficial dietary patterns have moderately strong evidence in risk reduction of CVDs (36%), T2D (21%) and colorectal and breast cancer.

Recommendations for diet

The US Dietary Guidelines Advisory Committee recommends an adequate intake of fruit, vegetables and wholegrains, followed by moderate intake of low-fat dairy products, seafood, legumes and nuts and reducing consumption of calories, sugar, salt, alcohol, refined grains and red and processed meat (Kimokoti & Millen, 2016). Moreover, the Scientific Advisory Committee on Nutrition (2019) adds that a multitude of RCTs and cohort studies recommended lowering saturated fat to reduce the risk of CVD. The Singaporean dietary guidelines (HPB, 2019c) are aligned with the aforementioned recommendations and have adopted the US 'My Healthy Plate' guidelines (United States Department of Agriculture, 2019). The guidelines (see Figure 2.1) emphasise diet quality and food types, encourage water intake and promote PA (HPB, 2019d). These guidelines are constantly updated to encourage positive dietary behaviours and meet the changing nutrient requirements of older adults.

Figure 2.1 My Healthy Plate guidelines (HPB, 2019d)

A qualitative study found Singaporeans reported that these plate-based guidelines were simple and easy to understand (HPB, 2019d). Thus, a nutrition expert committee devised guidelines to improve the nutritional status of Singaporean adults aged ≥50 years old (HPB, 2019c; Lee, 2011):

- Have meat, fish, chicken, eggs, tofu or lentils in every meal (see Figure 2.2).
- Have three servings of meat and other alternatives daily.

Figure 2.2 Examples of one serving of meat and other alternatives (HPB, 2019d)

- Replace refined grains with wholegrains. Include at least one serving of whole grains daily (see Figure 2.3).

Figure 2.3 Examples of one serving of wholegrains (HPB, 2019d)

- Have two servings of fruit (see Figure 2.4) and two servings of vegetables daily (see Figure 2.5).

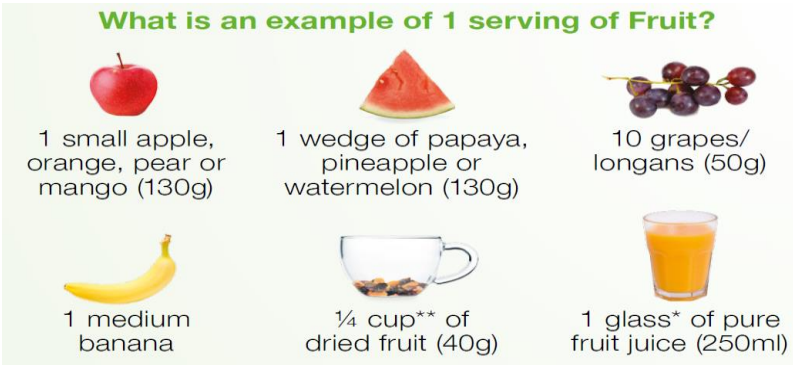


Figure 2.4. Examples of one serving of fruit (HPB, 2019d)

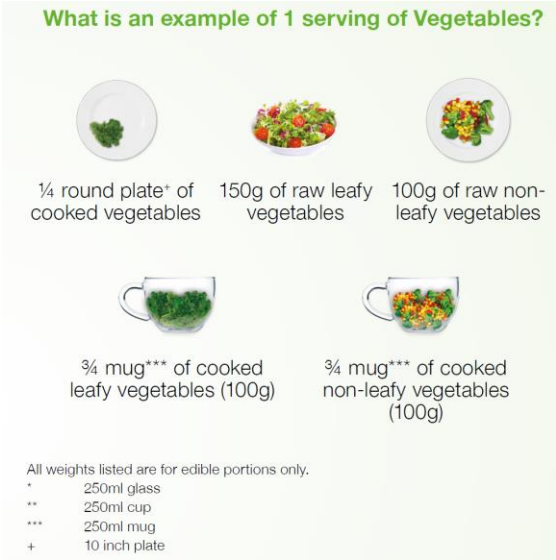


Figure 2.5 Examples of one serving of vegetables (HPB, 2019d)

- Eat more calcium-rich foods, such as calcium-fortified soymilk, tofu, milk, cheese and yoghurt.
- Use oils with a healthier choice symbol or unsaturated fat like olive or sunflower oils instead of lard, ghee or palm oil.
- Consume water or unsweetened drinks (tea) instead of soft drinks or sugar-sweetened beverages.
- Drink at least eight glasses of water a day.
- Eat sweet desserts and snacks less often.
- Use less salt and sauces. Reduce salted and preserved foods.

Measures of diet

Nutrition assessment methods evaluate the connections between dietary patterns and risk factors of NCDs. Dietary patterns describe the quantity and quality of foods and drinks habitually consumed (United States Department of Agriculture, 2014) and are measured by dietary assessment tools (Schulze et al., 2018). Diet history, 24-hour recall, food frequency questionnaires, screeners (brief focused questionnaires) and biochemical markers are tools with varying strengths and drawbacks (Labonte et al., 2016). Diet history, 24-hour recall and biochemical markers are very demanding of study participants, resulting in high investigator burden and costs and are less feasible for large-scale studies (Labonte et al., 2016; Shim, Oh, & Kim, 2014).

On the other hand, food frequency questionnaires and screeners are cost-effective and require less time but are prone to recall bias and measurement errors (Kirkpatrick et al., 2014; Shim et al., 2014). The WHO STEPS instrument consists of a dietary screener (8 questions) to collect and monitor data on NCD risk factors in over 122 countries (Kirkpatrick et al., 2014; Riley et al., 2016). It has been adopted by nations worldwide to understand food consumption patterns (WHO, 2019c) and was used in SG to assess weekly consumption of salt, fat, sugary beverages, wholegrains and fruit and vegetables (HPB, 2013). Therefore, this screener is a simple and cost-effective tool in analysing dietary patterns and developing appropriate nutrition interventions for high-risk populations.

2.5 Behavioural change interventions and theoretical frameworks

Primary prevention interventions target metabolic risk factors in healthy individuals before the development of the disease stage (Probst-Hensch et al., 2011). In contrast, secondary prevention interventions detect newly diagnosed NCDs and conduct interventions to reduce disease progression (Ali & Katz, 2015; Arena et al., 2015; WHO, 2012). The section below provides the effectiveness of community-based interventions in NCD prevention globally and within Asia. In addition, theoretical frameworks targeting PA and dietary behaviours of older adults will also be discussed.

2.5.1 Global populations

Community-based interventions are usually multi-component, including behavioural and/or environmental strategies to promote PA and healthy eating practices among population groups at a community level (Brand et al., 2014). Such interventions have positively improved behaviours and/or health outcomes in older adults at risk of CVD, overweight and obesity and T2D.

Physically inactive communities

Two RCTs of 6 months duration targeting insufficiently active (<150 minutes of weekly moderate PA) Australian adults (mean age 69 years) were conducted in homes and retirement villages (Burke, Lee, et al., 2012; Jancey et al., 2017). In both studies, intervention participants received resources (booklets, calendars and

resistance bands) and were followed up via phone calls and emails. The intervention group in the 'Retirement Village PA and Nutrition Study' displayed statistically significant mean improvements in the fruit intake, strength exercise and weight loss compared to the control group (Jancey et al., 2017). Awhile, the intervention group in the other 'PA and Nutrition study' demonstrated statistically significant mean improvements in walking and vigorous PA, fruit intake and WHR (Burke, Lee, et al., 2013; Burke, Lee, et al., 2012). No changes were found in BMI, moderate PA or vegetable and fibre intake in both studies, which may be limited by the lack of meetings with health professionals. PA and dietary habits of older adults improved significantly when supported by frequent contact with professionals and longer duration of group-based sessions (Patnode et al., 2017). Both studies highlighted that objective measures of PA and a longer follow-up period could enable better measurements of behavioural changes and program effectiveness. Nonetheless, home-based interventions allow greater flexibility within older adults' residences to improve behavioural and health outcomes.

Cardiovascular disease

Two reviews of PA and dietary interventions (n = 49–79) with a duration of 6–54 months in obese adults (mean age 58 years) with dyslipidaemia, high BP, IGT and MetS improved CVD risk factors (Lin et al., 2014; Zhang et al., 2017). Both studies achieved statistically significant mean improvements in TC (−0.11 mmol/L), LDL-C (−0.09 mmol/L), systolic BP (−2.1 mm Hg) and diastolic BP (−1.6 mm Hg). Such improved outcomes may be associated with a longer program duration (median 12 months) conducted by professionals trained in behavioural change techniques (BCTs) over a longer session (median 16 hours). A BCT is "a replicable strategy used in interventions to generate a desirable targeted behaviour" (Michie et al., 2015, p. 2). In addition, such improvements were reported in studies of 12 months of follow-up but only BP and HDL-C levels were sustained after 24 months. More studies should investigate factors that affect the effectiveness of such interventions on health outcomes >12 months.

Overweight and obesity

Two reviews of PA and dietary modification (n = 21–56; most of them were of 6 months duration) in obese (BMI ≥34 kg/m^2) adults provided moderate-quality evidence to support long-term obesity management (Baillot et al., 2015; Schwingshackl, Dias, & Hoffmann, 2014). These studies yielded statistically significant mean reductions in weight (-8 kg), WC (-5 cm), diastolic BP (−3.4 mmHg) and TC (−0.64 mmol/L). Health-related quality of life (HR-QOL) indicators such as physical function and body pain were displayed in longer interventions of ≥12 months compared to interventions of <6 months. The frequency of contact (>2 sessions/month) with health professionals was reported to be inversely associated with weight, BMI, WC and systolic BP ($p \leq 0.003$) (Baillot et al., 2015). Moreover, Jensen et al. (2014) reported that professionals using BCTs achieved a clinically meaningful weight loss of 3%–5% of body weight (-8 kg) within 6 months in overweight and obese adults. However, the heterogeneity of PA modalities (aerobic and resistance training) and dietary components (low-calorie and low-fat) hinder the identification of the most effective strategies for targeting overweight and obese adults. Future research can explore appropriate strategies to deal with weight loss plateaus and promote additional weight loss for periods of ≥12 months for older adults.

Pre-diabetes

Two reviews of PA and dietary RCTs (n = 36, >14 months) on adults with IGT revealed statistically significant mean reductions in BG (−0.18 mmol/L), systolic BP (−2.77 mm Hg), TG (−0.26 mmol/L) and BMI (−1.61 kg/m^2) ($p < 0.001$) and T2D incidence risk (4%–22%) in the intervention relative to the control group (Appuhamy et al., 2014; Yoon, Kwok, & Magkidis, 2013). However, the authors commented that the benefits were more evident in adults with existing IGT than in normoglycemic adults. Similarly, another review of 30 PA and nutrition studies achieved statistically significant mean improvements in T2D incidence risk ratio (0.59), weight (−2.2%) and BG (−0.12 mmol/L) in obese women with pre-diabetes (Balk et al., 2015). Out of these studies, a four-year Finnish Diabetes Prevention study resulted in a statistically significant lower T2D cumulative incidence in intervention participants (11%) with IGT (mean age 55 years) who achieved at least 4 out of 5 PA and dietary goals compared to the control group (23%) (Tuomilehto et al., 2001). The 13-year

follow-up of this Finnish study by Lindström et al. (2013) shows that the intervention group sustained lower T2D cumulative incidence (44%) than the control group (64%) with reductions in weight, fasting and two-hour plasma BG post-intervention. However, these findings were based on self-reported behaviours and apply only to adults with IGT.

Metabolic syndrome

A review of 12 PA and dietary RCTs with and at risk of MetS showed statistically significant mean decreases in TG (-0.12 mmol/L) and WC (-2.4 cm) (Blackford, Jancey, Lee, James, Waddell, et al., 2016; Yamaoka & Tango, 2012). In addition, the 'Albany PA and Nutrition' program in Australian adults (mean age 60 years) displayed statistically significant improvements in CVD risk score (−0.82) ($p \leq 0.04$) and moderate-intensity PA, fibre intake, vegetable servings and fat intake ($p = 0.049$) in the intervention group compared to the control group from baseline to post-test. The authors of the Australian study attributed these positive results to the usage of tailored web-based message and printed resources, supported by phone-based motivational interviewing (MI) strategies to motivate healthy behaviours. However, the majority of these studies on adult populations with MetS were of 6 months duration and longer follow-up periods are warranted to investigate the long-term T2D prevention.

Type 2 diabetes

In the one-year 'Action For Health in Diabetes' RCT, overweight and obese US adults (n = 5000, mean age 59 years) with T2D displayed statistically significant improvements in glycaemic control that were associated with weight changes ($p < 0.0001$) but this trial was limited by a lack of objective measures of PA (Wing et al., 2011). A longer-duration study, the five-year ADDITION-Cambridge trial, found that the relative risk for CVD events in adults who did not modify any PA and dietary behaviour compared to those who changed ≥3 behaviours was 4.17, independent of medication use, for newly diagnosed T2D adults (n = 867; mean age 61 years) (Long, Cooper, Wareham, Griffin, & Simmons, 2014). The authors commented that using self-reported measurements may have introduced measurement bias and the findings cannot be generalised to adults without T2D.

2.5.2 Asian populations

Previous research in PA and dietary interventions have focused largely on Western nations, making the results difficult to generalise to Asian populations. To date, the robustness of Asian studies is lacking with limitations such as small sample sizes, absence of power calculations and lack of accounting for confounders to justify the validity of the findings. The paucity of well designed community-based RCTs targeting older adults' PA and dietary behaviours and health outcomes in Asia, particularly in Singapore, should encourage more researchers to investigate the efficacy of such intervention.

Quasi-experimental research

Six-month studies

Two PA and dietary interventions were conducted by nurses, dieticians and physiotherapists. These studies included the 'Koryo' study with Japanese women (mean age 62 years) within public health centres and the 'My Body Fit and Fabulous' study for overweight Malaysian women (mean age 48 years) in the home environment (Mohd Zaki et al., 2018; Uritani et al., 2013). After 6 months, statistically significant decreases were found for WC, BMI, body fat and weight for the Japanese intervention group (Uritani et al., 2013) but only weight loss was observed for the Malaysian intervention group (p <0.02) (Mohd Zaki et al., 2018) compared to their respective control groups.

Both studies reported on the use of BCTs by health professionals that may increase the participants' self-efficacy. As advocated by Menichetti, Cipresso, Bussolin, and Graffigna (2016), these techniques can empower older adults to stay physically active and eat well. However, the short duration (≤45 minutes) of low-intensity PA (muscle-strengthening or flexibility) and short intervention period may be insufficient to detect improvements in BP, anthropometric and HR-QOL indicators. The authors from both studies acknowledged the need for longer duration and higher intensity sessions to confer improvements in outcomes. Another study provided PA instruction for Japanese adults with MetS (mean age 62 years) from nurses and dietary support from nutritionists (Ohno et al., 2015). Although this study achieved statistically significant reductions in weight and BP (p <0.04), its limitations are consistent with the two previous six-month studies—small sample sizes (28–255)

possibly prone to selection bias because of the recruitment of positively motivated older adults.

12-month studies

Two larger quasi-experimental studies (n = 270–12,600) at government-supported health centres targeting pre-diabetic adults (mean age 52 years) included the Malaysian 'Community-Based Healthy Lifestyle Intervention Program' (Co-HELP) and 'Seoul Metabolic Syndrome Management' (SMESY) study (Ibrahim, Ming Moy, Awalludin, Mohd Ali, & Ismail, 2016; Lee et al., 2013). Both intervention groups attended face-to-face counselling session by dietitians but the Malaysian study also included monthly group-based PA and nutrition sessions (90 minutes per session). Statistically significant improvements in BG, BP, HDL-C were displayed in both intervention groups compared to their respective control groups.

Positive outcomes in both studies may be due to the use of underpinning theories, BCTs and appropriate health resources. Moreover, Ibrahim et al. (2016) contended that the collaborative partnership among the participants, research team, community volunteers and practitioners may have resulted in high retention of participants (88%) in the Co-HELP study. Conversely, there was a low participation rate in counselling sessions (24%) for the SMESY study. Lee et al. (2013) suggested that more counselling sessions at convenient times at multiple centres may improve participation rates. The authors of both studies implied that positive results could be biased by the enrolment of health-conscious participants. Hence, future research should explore the use of RCTs in the design of studies to minimise research bias.

Randomised controlled trials

Community dwelling adults

A one-year 'Sumida TAKE 10!' study promoted ten minutes of PA twice daily and encouraged regular meals from food groups (n = 10) in Japanese adults (mean age 78 years) (Kimura et al., 2013). The intervention group attended healthy eating sessions (30 minutes per session), followed by PA (60 minutes per session) fortnightly (Kimura et al., 2013). Post-test results reflected statistically significant increases in the frequency of fruit, seaweed, fish and eggs intake with no changes in the frequency of walking, stretching and muscle-strengthening PA in the intervention

group compared to the control group (Kimura et al., 2013). The authors highlighted that participants (78%) were already engaged in the recommended PA levels and may have stayed indoors during the winter months of the intervention period. Future studies could recruit participants who do <150 minutes of PA weekly and conduct process evaluation to inform on the effectiveness of the program.

In comparison, a six-month RCT for Taiwanese adults (mean age 60 years) at risk of high BP and hyperlipidaemia have statistically significant improvements in self-efficacy scores, systolic and diastolic BP, BMI and HDL-C ($p = 0.017$) in the intervention group compared to the control group (Wu et al., 2019). Such improved health outcomes may be due to the use of verbal persuasion and feedback by nurses or physicians during face-to-face sessions and follow-up calls. Longer follow-up time frames are required to detect changes in BG and TG. Future studies should include underpinning theory to guide and validate the measurement outcomes.

Impaired glucose tolerance

The longitudinal 30-year Da Qing Diabetes Prevention study reported that the intervention group of overweight (BMI = 26 kg/m2) China adults with IGT achieved a statistically significant mean delay in the onset of T2D (3·96 years) compared to the control group ($p < 0.004$) (Gong et al., 2018; Qian et al., 2018). The authors attributed these results to increased PA and healthier diets (high vegetable intake and low alcohol and sugar intake) that delayed the onset of T2D in the intervention group compared with the control group. However, these findings cannot be generalisable to other pre-diabetic groups.

Metabolic syndrome

Two other six-month RCTs were the 'Korean Metabolic Syndrome' study and Vietnam PA and Nutrition Study (VPANS) targeting adults (mean age 62 years) with MetS (Tran, Lee, et al., 2017; Yoo, Kim, & Cho, 2012). Both interventions provided education classes and information booklets. Strategies included face-to-face or phone counselling sessions with health diaries in the Korean study and walking groups with resistance bands for the VPANS. At post-test, statistically significant improvements were reported in abdominal obesity, BP, TG and dietary intake ($p = 0.030$) for the Korean intervention group while statistically significant improvements were found in

PA levels, sitting time, anthropometric measures and HDL-C (p = 0.018) for the VPANS intervention group compared to their respective control groups.

No significant changes in other lipid outcomes and BP in these studies may have been impacted by the duration, intensity and types of PA. For instance, high-intensity aerobic and more repetitions in muscle-strengthening PAs on adults achieved statistically significant reductions in LDL-C and TG in a review of 10 studies (Mann, Beedie, & Jimenez, 2014). High-intensity cycling (40 minutes daily for five days per week) by obese, sedentary Indian adults displayed statistically significant reductions in LDL-C and diastolic BP (Kannan et al., 2014). Singaporean adults reported that higher step intensity and not amount had a statistically significant reduction in diastolic BP (p <0.01) (Sumner et al., 2020). However, the aforementioned PA studies had small samples (n = 16–235) of young adults <50 years old. Future research is needed to investigate pragmatic components of PA to improve health outcomes in older adults.

Type 2 diabetes

Two theory-based RCTs of three months duration were conducted on Malaysian adults (mean age 47 years) with abdominal obesity (WC >90 cm) at risk of T2D or diabetic adults (Soon, Abu Saad, Taib, Abd Rahman, & Mun, 2013; Tan, Magarey, Chee, Lee, & Tan, 2011). Both studies included face-to-face sessions and follow-up phone calls conducted by professionals. However, the study on diabetic adults included counselling sessions using self-efficacy approaches, while in the other study, adults with abdominal obesity engaged in group PA sessions and received accelerometers and pedometers for PA measurements.

Results from the study for diabetic adults reported statistically significant improvements in self-monitoring of BG, diabetes knowledge and haemoglobin A1c (HbA1c) levels (p = 0.001) in the intervention group compared to the control group. For the study on adults with abdominal obesity, a statistically significant reduction was achieved only in fasting BG (p = 0.02) in the intervention group compared to the control group. A possible explanation for improvements in the program for diabetic adults may be the use of verbal persuasion to increase self-efficacy. Incorporation of such BCTs may influence participants to integrate their behaviours with their goals,

given the brief program duration. Future research of longer duration should explore effective BCTs to sustain behavioural changes and improve health outcomes.

Systematic reviews

PA and dietary modification RCTs in Thailand (n = 5) and Malaysia (n = 2) confirmed statistically significant improvements in BG and HbA1c ($p = 0.02$) in the intervention group participants compared to control group participants (mean age 50 years) at 3 months but not at 6 months (Htoo, Hsu, & Rosenkranz, 2016). However, most of these studies were limited by an intervention period of three months (except for two 6-month studies), small sample sizes (n = 43–164) and outdated, English-only publications (2006–2014). Another review showed that studies displayed improvements in BP, cholesterol, TG and HDL-C over a 6 to 12-month period; however, *p* values were not reported (Chapman et al., 2013). Only 4 out of the 119 studies met the inclusion criteria as a primary care-based intervention that quantitatively evaluated the efficacy of PA and/or dietary change intervention in South Asian populations (Chapman et al., 2013). The non-adjustment of confounders, lack of theory and objective measures of PA in almost all the studies increased the difficulties in interpreting the outcomes. Likewise, a review of PA and nutrition interventions (n = 8) by Brand et al. (2014) recommended that all research studies should conduct a process evaluation to increase research validity.

2.5.3 Theoretical framework

2.5.3.1 Social Cognitive Theory

Social Cognitive Theory (SCT) is an effective framework for guiding behavioural changes in PA and dietary interventions among older adults. It relates to the complex interaction among personal factors, environment and human behaviour (Bandura, 1986; Glanz, Rimer, & Viswanath, 2008). SCT was widely considered to be an effective framework across 155 behavioural interventions to modify behaviour changes in adults aged ≥50 years old (Gourlan et al., 2016; Stacey, James, Chapman, Courneya, & Lubans, 2015; Young, Plotnikoff, Collins, Callister, & Morgan, 2014). Psychosocial constructs of SCT include outcome expectation (cognition), reinforcement (behavioural influence), observational learning and social support (environmental impact) (Bandura, 1986; Glanz et al., 2008). Its foremost construct is self-efficacy, which examines the belief in one's ability to perform tasks that produce

results (Anderson, Winett, Wojcik, & Williams, 2010). Two studies displayed positive PA and dietary changes that were observed in adults (mean age 54 years) with high self-efficacy using self-regulatory and self-monitoring strategies to cope with barriers to change (Anderson et al., 2010; Brand et al., 2014). A variety of SCT and its constructs should be applied in interventions for explaining and monitoring positive behaviours in older adults.

2.5.3.2 Social-Ecological Model

Due to the complexity of human behaviours, the Social-Ecological Model (SEM) explores the interaction of socio-environmental factors that can shape PA and dietary changes in older adults. It is most effective when the individual, social and environmental contexts are targeted simultaneously (Golden & Earp, 2012). This model guides strategies for enhancing the appropriateness of the RC settings and surrounding social networks in reinforcing health practices. The example below illustrates how these factors may influence behaviours:

- Individual: knowledge, skills, motivation, attitude and belief to engage in health practices.
- Interpersonal: peer support and social network to motivate positive behaviours.
- Community: collaboration of RC managers and volunteers at neighbourhood RCs to motivate participants to stay fit and eat well.
- Organisation: partnerships between the government and health agencies to support relevant PA and dietary programs.
- Policy: long-term access to low-cost activities and adaptable facilities supported by the government.

Thus, the SEM is a multi-faceted framework designed to account for socio-environmental factors that influence PA and dietary behaviours of older adults (Anderson et al., 2010; Boulton, Horne, & Todd, 2018; Chaudhury, Campo, Michael, & Mahmood, 2016; Richard, Gauvin, & Raine, 2011). It underlines the fact that practitioners should work with relevant stakeholders to sustain and influence behavioural changes through structural change.

2.6 Effectiveness of strategies used in behavioural change intervention

Considering that policymakers should invest in behaviour change interventions to adopt positive health practices, future studies need to identify the most practical ways to achieve positive outcomes. The following section summarises psychological techniques and delivery modes used in PA and/or dietary interventions targeting older adults.

Psychological techniques

Behavioural change techniques

In a review of 22 RCTs (mean duration 19 months), BCTs such as social support and problem solving were found to increase fruit and vegetable intake among healthy adults (mean age 62 years) (Lara et al., 2014). McEvoy et al. (2018) incorporated goal-setting and action planning into a 12-month program to encourage adherence to a Mediterranean diet for adults at risk of CVDs. For glycaemic control, 13 RCTs using behavioural practice and action planning significantly reduced weight (2.7−3.6 kg) and HbA1c (7−12 mmol/mol) at 3 to 6 months for adults (mean age 57 years) with T2D (Cradock et al., 2017). Self-monitoring reduced weight for 11,200 overweight adults aged ≥40 years old in 48 RCTs ranging from 3−12 months or more (Samdal, Eide, Barth, Williams, & Meland, 2017). Provision of personalised feedback for 3600 diabetic adults (mean age 58 years) was associated with a significant reduction in HbA1c (Cheng et al., 2017). Such feedback when facilitated by professionals trained in MI increased participants' (n= 6400; median age 51 years) motivation and reduced their MetS risk factors in a review of 28 RCTs (Bassi et al., 2014).

Motivational interviewing

Alongside BCTs, MI techniques are frequently used to stimulates motivation in PA and dietary practices. It resolves adults' ambivalence and promotes their decision-making behaviour (Rollnick et al., 2010). It is most useful when rapport is developed through information sharing (Cozolino & Santos, 2014) and delivered in a face-to-face mode (Ogedegbe et al., 2013). Application of such techniques sustained PA and dietary changes in reviews of 68 RCTs of obese populations (mean age 48 years) (Barrett, Begg, O'Halloran, & Kingsley, 2018; O'halloran et al., 2014; Samdal et al.,

2017). Moreover, positive PA and nutrition modifications improved weight, BP, BMI, BG, body fat percentage and cholesterol levels in studies ranging from 6−12 months (Browning et al., 2016; Chee et al., 2017; Hardcastle, Taylor, Bailey, Harley, & Hagger, 2013). Another 3-month telephone-based program with MI techniques conducted on Taiwanese women (mean age 64 years) with MetS demonstrated a reduction of MetS diagnoses (Lin et al., 2016). However, it is not well understood if the heterogeneity of professionals such as nutritionists and physiologists with varying proficiency in MI techniques may impact the effectiveness of behavioural and health outcomes. As argued by Weisner and Satre (2016), the effects of the provider's MI skills on motivating participants' behaviour and outcomes remain in dispute, which demands more research in this area.

Motivators

A review of 19 PA interventions lasting >12 months by Zubala et al. (2017) found that intrinsic motivators such as societal belonging, enjoyment and social networks enhanced group-based participation for adults (mean age 70 years). Moreover, adults were intrinsically motivated to participate in regular face-to-face contact sessions with exercise specialists in another review of 17 PA studies (Bock, Jarczok, & Litaker, 2014). Strong peer relationships that developed during counselling and mentoring programs also increase PA compliance rates in adults (mean age 65 years) (Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014). On the other hand, extrinsic motivators such as instructor-led, low-cost government-subsidised activities supported PA behaviours of inactive older female communities worldwide (Heath et al., 2012). In Singapore, supermarket vouchers and cash were preferred incentives by adults (mean age 60 years) to participate in PA programs, but the affordability and sustainability of this strategy remain to be established (Farooqui, Tan, Bilger, & Finkelstein, 2014). Most of these motivators provide short-term PA adherence (≥6 months). Future research should focus on determining if intrinsic and/or extrinsic motivators are effective in long-term PA maintenance.

Self-efficacy

The strongest determinant that motivated PA participation in healthy adults (mean age 44 years) was self-efficacy, which relates to an individual's belief in one's ability to be physically active (Choi, Lee, Lee, Kang, & Choi, 2017). Bauman et al. (2012)

reported that self-efficacy was positively correlated with PA levels in adults. Another study by Warner, Ziegelmann, Schuz, Wurm, and Schwarzer (2011) reported that German adults (n = 390, mean age 75 years) with higher self-efficacy were more active. Moreover, self-efficacy not only encouraged participants to increase PA levels at 3 months but also sustained such activities for 6 months in the intervention group relative to the control group (Ory et al., 2018). Sullivan and Lachman (2017) suggested increasing self-efficacy by monitoring PA using smartphone apps and Fitbits. For instance, the wearers monitor and get real-time feedback on their progress on these devices, which increases their self-efficacy and eventually fosters long-term PA practices. Although using such devices to increase self-efficacy in PA levels is promising, future research should create practical messages that inform on improvements needed based on PA intensity, frequency and duration.

Delivery mode

Mobile apps

Mobile apps are promising platforms for behavioural change due to the ubiquitous ownership of such devices, frequent use of free apps like WhatsApp and good network connectivity in Singapore. Kimokoti and Millen (2016) advocate their use to 1) communicate with professionals, 2) assess data analytics and monitor behaviours and 4) aid frequent feedback to enhance participants' motivation. In a review of nine interventions, text messaging displayed low-to-moderate effectiveness in facilitating behavioural and health outcomes (Hall, Cole-Lewis, & Bernhardt, 2015). However, Stephens and Allen (2013) reported significant improvements in PA levels and reduction in sugar intake, weight, BMI and WC in seven mobile apps studies among adults (mean age 42 years). Another review of 12 mobile app-based RCTs showed significant improvements in PA levels, SB, diet, weight, BP and cholesterol in adults (mean age 42 years) (Schoeppe et al., 2016). However, the non-rigorous study designs with brief intervention periods (≤6 months) undermine their validity. Major drawbacks included mostly Western studies (except for Korea) and in adults <50 years old. Pfaeffli Dale, Dobson, Whittaker, and Maddison (2016) also questioned the efficacy of mobile apps in promoting behavioural change due to inconsistent reporting of outcome measures and intervention characteristics. Hall et al. (2015) recommended more research to verify the cost-effectiveness of mobile phone apps designed for long-term behavioural change.

Trained professionals

Aside from technological devices, behavioural change interventions delivered by trained professionals such as dietitians and nurses, are practical strategies to improve weight management in older adults. For example, Borek et al. (2018) reported clinically meaningful mean weight losses (-3.2 kg) on overweight and obese adults comparing the intervention groups relative to control groups in such behavioural change RCTs (n = 48; duration 6−24 months). Moreover, dietitian-delivered T2D programs demonstrated greater effectiveness in weight loss (-1.7 kg) in adults than those delivered by non-dietitian professionals in a review of 65 PA and dietary interventions (Sun, You, Almeida, Estabrooks, & Davy, 2017). However, such interventions delivered by health professionals may be costly in long-term interventions. Hence, Sun et al. (2017) recommended future studies to investigate the cost-effectiveness of this strategy.

Tailored components

Health professionals providing personalised feedback and recommendations for action planning and giving meaningful resources were associated with improved nutrition modifications in adults (mean age 34 years) (Whatnall, Patterson, Ashton, & Hutchesson, 2018). Another review of 44 RCTs reported that customised dietary interventions with prompt advice supported modest improvements in dietary fibre, fruit and vegetable intake and reduced saturated fat and energy intake (Rees, Dyakova, Ward, Thorogood, & Brunner, 2013). In addition, reductions in BP, TC and LDL-C were achieved for adults who received dietary counselling compared to those who did not. Across these studies, tailored feedback and the involvement of participants in building their problem solving skills may have facilitated dietary modifications. Kimokoti and Millen (2016) recommended using personalised risk profiles as baselines to plan targeted dietary interventions and pinpoint areas in which the participants did not adequately meet dietary guidelines.

2.7 Settings of interventions to support healthy behaviours

Since older Singaporean women are frequent users of the ubiquitous RCs (Wong et al., 2019), research is needed to investigate how determinants of the RCs' environment influence health practices. Such investigations can monitor behavioural trends, develop effective interventions and evaluate policies that consequently improve their health outcomes (Hyseni et al., 2017; Mikkelsen et al., 2019). The section below reviews the effects of RCs' built and social environment on PA and dietary behaviours of older adults.

2.7.1 Built environment

The built environment includes buildings, land-use patterns and environmental features as a medium for social interaction to improve health practices (Bloch et al., 2014). Since older adults spend time mostly within their neighbourhood and their mobility decreases as they age, more research should be conducted on the built environment such as the neighbourhood features surrounding the RCs and parks conducive to promoting PA.

2.7.1.1 Physical activity behaviours

Neighbourhood features

An increase in walking was observed for adults aged ≥65 years living in a walkable area, reported in a review of 23 environmental studies (Haselwandter et al., 2015). Desirable commuting attributes for adults (mean age 72 years) included short distance to shops, social venues and fitness facilities (Inoue et al., 2011), as well as nearby convenience stores and health amenities (Nathan, Wood, & Giles-Corti, 2014). Furthermore, Wang and Qiu (2016) reported that older adults (without vehicle ownership) walk or cycle to shop for groceries. Well-maintained pedestrian infrastructures and lighting (Chaudhury et al., 2016; Van Holle et al., 2014) and good crosswalks and sidewalks connectivity (Inoue et al., 2011; Yoshinobu, Yuko, Shigeru, Ayumi, & Yoshitaka, 2013) supported residents' walking levels (mean age 62 years). The visibility and usability of benches and the absence of litter and graffiti increased walking among older adults (mean age 80 years) (Etman et al., 2014). Low crime areas and less traffic density were associated with higher moderate to vigorous PA levels in adults aged ≥55 years old (Prins, Kamphuis, de Graaf, Oenema, & van Lenthe, 2016; Stathi et al., 2012). Conversely, environmental barriers (lack of resting

spots and walking paths, bad weather and lighting) impede adults' (mean age 68 years) PA levels (Rosenberg, Huang, Simonovich, & Belza, 2012).

Parks

Neighbourhood park venues can be integrated into older adults' routine to increase activity levels. For instance, underutilised spaces, footpaths, cycle lanes and trails provide free PA opportunities (Evenson, Wen, Hillier, & Cohen, 2013). Park agencies, health providers, community partners and individuals should collaborate to plan more efficient park utilisation (Salvo, Lashewicz, Doyle-Baker, & McCormack, 2018). As perceived by Giles-Corti et al. (2015), the park where a majority of older adults spend their leisure time, is a potential venue to increase PA levels. The accessibility of green spaces such as parks within adults' neighbourhoods was associated with weekly participation in walking and moderate to vigorous PA in adults (mean age 62 years) (Astell-Burt, Feng, & Kolt, 2014). Moreover, higher park usage was linked to attractive facilities and convenient PA classes (Salvo et al., 2018) as well as regular park maintenance, serene landscape, easy access and shaded facilities for adults (Costigan, Veitch, Crawford, Carver, & Timperio, 2017). However, these studies were confined to Western populations and more qualitative research in other populations are required to generalise these findings.

Singaporean adults (medium age 53 years) reported engaging in walking, cycling or fitness sessions due to the parks' pleasant landscape, greenery and facilities (Léonie et al., 2019). The results of a six-month park study comprising of weekly PA classes and phone counselling sessions revealed statistically significant increases in recreational PA and time spent in the park for the intervention group (n = 71) compared to the control group (n = 74) (Müller-Riemenschneider et al., 2020). Nevertheless, the authors recommended longitudinal studies with adequate sample sizes to validate the findings. Given the high accessibility of 400 well-distributed parks across Singapore and the fact that only 63% of the population visit them bimonthly (Léonie et al., 2019; National Parks, 2020), park usage should be maximised as cost-effective strategies for older adults to be physically active.

2.7.1.2 Dietary behaviours

Environmental facilitators to healthy eating included low cost and high accessibility to healthy foods that increase older adults' abilities to make healthy eating decisions (Belon, Nieuwendyk, Vallianatos, & Nykiforuk, 2016). Environmental food research relating to dietary practices was conducted mainly in the US, Canada and Europe (Li & Lopez, 2016). Availability of nutritious food in the built environment such as the recreational centres and neighbourhood food amenities may influence older adults' ability to eat healthily.

Recreational centres

Community gardens and vending machines at RCs can be targeted to facilitate dietary changes in older adults. For instance, the development of community gardens can increase the availability and accessibility of healthier food produce (Wong et al., 2019). A growing body of literature has shown that community gardeners who grew fruit and vegetables had a higher intake of such produce, reduced their fast food consumption and achieved affordable, sustainable healthy food access compared to non-gardeners (Gray, Guzman, Glowa, & Drevno, 2014; Wood, Pretty, & Griffin, 2016). In addition, stocking healthier products in the vending machines may stimulate healthy snacking (Wong et al., 2019). Increased purchases of low-priced healthier choice products with a point of purchase (POP) nutrition labelling were observed in a review of 12 nutrition interventions (Grech & Allman-Farinelli, 2015). POP nutrition labelling is information placed on the food item to promote a specific nutrient or claim (Volkova & Ni Mhurchu, 2015). However, only two out of 12 RCTs highlighted that POP nutrition labelling promoted healthier food choices (Grech & Allman-Farinelli, 2015). Moreover, this purchasing behaviour was observed to be higher in educated females with health concerns (Van't Riet, 2012; Volkova & Ni Mhurchu, 2015). More studies should investigate the efficacy of POP nutrition labelling and the availability of low-cost, healthier choice products in vending machines to encourage purchasing habits among older adults.

Neighbourhood food amenities

Neighbourhood supermarkets and eateries can influence older adults' dietary intake. The proximity of supermarkets to residents' homes (within 3 kilometres) allows diverse access to a variety of fresh food, helping to initiate a healthy diet (Wang & Qiu, 2016). Moreover, the availability of nutrition-dense foods in supermarkets influenced healthy eating behaviours (Meyer et al., 2015). In contrast, cheap and unhealthy foods in convenience stores were associated with poor eating habits and higher obesity rates (Yan, Bastian, & Griffin, 2015). In Singaporean supermarkets and eateries, there is a surge in the sales of poor quality foods laden with saturated fats, sugar and salt. Singaporean women aged ≥40 years perceived these unhealthy foods as attractive options due to their low cost and convenience (Naidoo et al., 2017). More research should be targeted at such amenities to increase older adults' awareness that healthy food is readily accessible and affordable to promote healthy dietary practices.

2.7.2 Social environment

Extensive research on older adults shows that socially connected relationships persuade them to stay active and eat well. Getting adults to be physically active is enriched when they interact with other peer-aged adults in community activities (Stathi et al., 2012). The following section provides an overview of the social environment in supporting relationships among older adults by creating an optimal medium for effectively supporting PA and dietary behaviours.

2.7.2.1 Physical activity behaviours

Older adults (mean age 77 years) forge relationships through communal programs within their neighbourhood RCs that increased their PA levels (Brown et al., 2011; Chang, Wray, & Lin, 2014). Informal chance encounters between participants within the RCs' neighbourhood environment also promoted active lifestyles (Ball, 2012). Social contact enhanced the PA levels of adults (mean age 59 years) (Bloch et al., 2014; Chaudhury et al., 2016) as it fostered companionship and reduced loneliness (Bauman et al., 2012; Lindsay Smith, Banting, Eime, O'Sullivan, & van Uffelen, 2017). Oyibo, Adaji and Vassileva (2018) remarked that social connections had a stronger effect on increasing American women's PA levels compared to men.

However, Oyibo et al. (2018) emphasised adding larger sample sizes from more countries and including objective measures of PA to address the study's limitations.

In Singapore, group-based interactions were associated with higher moderate to vigorous PA levels in adults (mean age 46 years) (Müller, Tan, Chu, van Dam, & Müller-Riemenschneider, 2019). Since older adults are motivated to maintain their PA levels through socialising, related stakeholders (individual role models, groups and organisations) may serve as catalysts to spur the growth of positive PA behaviours. For example, training interested volunteers to be walking leaders to establish groups and buddy systems improved activity levels and strengthen PA adherence (Prins et al., 2016). Ultimately, the impact of social contacts on motivating PA behaviours should be further explored to create effective group-based interventions for older adults.

2.7.2.2 Dietary behaviours

Social interactions are important determinants of dietary behaviours (Cannuscio, Hillier, Karpyn, & Glanz, 2014). For example, 25,500 single or widowed European adults above >50 years old were reported to have low protein, fruit and vegetable intake and less varied diets (Conklin et al., 2014; Ramic et al., 2011). Moreover, Japanese widowed adults or those living alone aged >75 years old had poor dietary intake and variety, leading to haemoglobin and zinc deficiencies (Tsuji et al., 2019; Wham, Teh, Robinson, & Kerse, 2011). Likewise, Tani et al. (2015) found that 82,000 Japanese adults aged >65 years old who ate and lived alone were associated with obesity, underweight and unhealthy eating behaviours.

On the contrary, social companionship improved the eating patterns of adults aged ≥52 years old and was inversely correlated with NCDs such as cancer (Steptoe, Shankar, Demakakos, & Wardle, 2013). A possible solution to increasing older adults' investment in healthy food preparation and eating practices is the creation of social networks via community gardening. Indeed, networks among gardeners (mean age 55 years) promoted nutritional awareness and reinforcement that resulted in a higher intake of fruit and vegetables (Algert, Diekmann, Renvall, & Gray, 2016; Barnidge et al., 2013; Lovell, Husk, Bethel, & Garside, 2014), greater accessibility and affordability of nutritious foods (Schmutz, Lennartsson, Williams, Devereaux, &

Davies, 2014; Wood et al., 2016) and lowering of gardeners' (mean age 48 years) BMIs (−2.1 kg/m^2) compared to non-gardeners (Zick, Smith, Kowaleski-Jones, Uno, & Merrill, 2013). Supported by a three-month RCT, gardening of vegetables and herbs increased social bonding among Singaporean adults (mean age 67 years) (Chan et al., 2017; Sia et al., 2018). Future studies should explore the effectiveness of community gardening and nutrition education to improve health outcomes.

2.8 Process evaluation

Process evaluation assesses effective program components in PA and dietary interventions that support behavioural and health outcomes. Many experts argue that it is necessary to perform such an evaluation to document program implementation, challenges and solutions (Haynes et al., 2014; Liu et al., 2016; Moore et al., 2014). Several researchers have used process evaluation in PA and dietary interventions to 1) achieve intervention fidelity, 2) assess intervention success or failure, 3) identify the causal relationship of intervention components to the outcomes, including dose satisfaction and program adherence, and 4) identify strategies (e.g., BCTs) to influence behavioural changes (Blackford et al., 2017; Burke, Jancey, et al., 2013; Jancey et al., 2018; Tran, Jancey, et al., 2017). Evidently, process evaluation provides valuable information into the effectiveness of the intervention and findings can be generalised into real-world settings.

However, most health interventions focus on describing impact and outcome evaluation instead of process evaluation, making it difficult to link intervention elements to their outcomes (Olstad et al., 2016; Viester, Verhagen, Bongers, & Van Der Beek, 2014). Furthermore, replicating studies is limited by poor quality in program descriptions and a lack of consistency in reporting process evaluation (Hoffmann et al., 2014). Liu et al. (2019) recognised these limitations and recommended the use of the 'Template for Intervention Description and Replication' checklist to allow better reporting of intervention characteristics. The 12-item list includes documenting intervention theory, setting and resources to assist in a study's replication (Hoffmann et al., 2014). As for the qualitative aspects of the evaluation process, the 'Consolidated Criteria for Reporting Qualitative' checklist was suggested to ensure the trustworthiness and completeness of the research (Tong, Sainsbury, & Craig, 2007). When combined, both checklists can provide more

details of the intervention components that increase the transferability of the study's findings.

The most critical part of the evaluation process is collaborating with the participants to identify the programs' strengths and weaknesses to improve program acceptability and sustainability (O'Hara et al., 2014). Such insights can better cater to the target group's needs and preferences and bridge the gap between their behaviours and health outcomes. Ultimately, process evaluation is pertinent to examine useful program elements to develop effective PA and dietary interventions.

2.9 Conclusion

Despite the magnitude of NCDs and the government's efforts to educate at risk older Singaporean women, the prevalence of chronic diseases has risen in this target group. Many PA and dietary interventions have positively addressed behavioural and health outcomes, but such studies were restricted to Western populations with limited rigorous research on Asian populations. Furthermore, variability in program components provides inconclusive evidence on effective components in modifying behavioural and metabolic outcomes. This literature review informs on three key considerations when developing a robust PA and dietary behavioural intervention for the target group.

Firstly, such an intervention should include multi-component strategies (face-to-face program delivery, practical educational resources and MI techniques) used by trained program ambassadors to improve older women's behavioural practices. When designing primary interventions, theoretical frameworks, BCTs and technology usage should be combined to support behavioural changes. Secondly, the determinants of built and social neighbourhood settings influencing their PA and healthy eating habits should be considered to create appropriate programs. Older women's perceptions, motivators and interests must be accounted for during the development of sustainable interventions. Long-term partnership and collaboration with stakeholders, including participants, the managers of RCs and the government, are integral to develop practical facilities and activities to nudge these women toward positive PA and dietary practices. Lastly, process evaluation provides a valuable framework to relate effective intervention components to behavioural and metabolic

outcomes. It pinpoints program barriers, gaps and challenges and modifies the program to meet participants' needs and sustain their program engagement. A comprehensive evaluation framework is essential to informing the design of future PA and nutrition behavioural intervention targeting older Singaporean women.

To conclude, multiple strategies, socio-environmental considerations and rigorous process evaluation are important components for developing a culturally appropriate PA and nutrition intervention. Based on our extensive literature search, no behavioural change intervention has been conducted for Singaporean women ≥50 years old who attend RCs. Therefore, a community-based RCT targeting this target group should be developed by considering the aforementioned components to support high program utilisation and sustainability. Findings from such intervention can contribute to valuable insights into NCD control and prevention in Singapore.

Chapter 3
Methodology

This chapter expands on the *protocol paper* (see **Publication 1,** Appendix B). It describes the study location, design, ethics, sampling and recruitment, intervention design, theory, formative evaluation, intervention program, data management plan, outcome measures and process evaluation.

This section addresses **objective 1:**

- Design and implement a six-month cluster randomised controlled trial (RCT) of a community-based intervention to improve physical activity (PA) and dietary behaviours of Singaporean women aged ≥50 years old attending recreational centres (RCs).

Related Publication:

- **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: Study protocol for a randomised controlled trial. *Trials*, 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

3.1 Study location

Singapore, a country in the Southeast Asia region (see **Figure 3.1**) was the study site for the Singapore Physical Activity and Nutrition Study (SPANS). There are five geographical districts in Singapore (see **Figure 3.2**), where 5.6 million people reside (SDOS, 2019). All five districts are of similar socio-economic status (SDOS, 2018b).

Figure 3.1 – Study location

(Nations Online, 2020)

Figure 3.2 – Five districts of Singapore

(Community Development Council Districts of Singapore, 2020)

3.2. Study design

A six-month cluster RCT targeting community dwelling women aged ≥50 years old attending RCs (n = 26) across five regions in Singapore constituted the study design. The trial was registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12617001022358, registration date 14 July 2017). Outcome measures were collected from the intervention and control groups at baseline and post-test (6 months). The proposed methodology and intervention were guided by the *Standard Protocol Items: Recommendations for Intervention Trials* (SPIRIT)

checklist (see **Appendix D**) and Template for *Intervention Description and Replication* (TIDieR) *checklist* (see **Appendix E)**. **Table 3.1** outlines the intervention process.

Table 3.1 Intervention process

Study groups	**(Baseline)** **0 months**	**Intervention**	**(Post-test)** **6 months**
Intervention group (N = 14, n = 295)	O_1	X	O_2
Control group (N = 12, n = 285)	O_1		O_2

O = Observation
X = Intervention
N = Number of recreation centres
n = Number of participants

3.3 Ethics

The research study was approved by the Human Research Ethics Committee at Curtin University (approval number: HRE2016–0366) (see **Appendix F**, *Ethics Approval*). Before the study, all participants attended a briefing session at their respective RCs to understand the study's aim, objectives and benefits. They were given an *Information Sheet* (see **Appendix G**) and a *Consent Form* (see **Appendix H**) that gave details of the nature of their involvement and an option for program withdrawal at any time. Participants had opportunities to ask questions and contact the research staff before they signed the consent form. Information collected was kept confidential and only aggregated data were reported in the publications.

3.4 Sampling and Recruitment

The PI and trained program ambassadors managed the screening, recruitment, intervention and data collection. The intervention was staggered over 18 months from October 2016 to March 2018. The post-test evaluation was completed in April 2018. A 25-item *CONsolidated Standards of Reporting Trials* (CONSORT) statement by Moher et al. (2010), guided the *CONSORT checklist* (see **Appendix I**) and *Flow Diagram* were used to report the study's procedures (see **Figure 3.4).**

3.4.1 *Power calculation and sample size*

The power calculation was based on a logistic regression model with the outcome variable being the prevalence of moderate-intensity PA participation. The sample size was determined similarly to previous PA and nutrition interventions for older adults (Blackford, Jancey, Lee, James, Howat, & Hills, 2015; Tran et al., 2016) but the clustering effect was not accounted for in the sample size calculation. The calculated sample size of 480 participants (240 participants per group) allowed sufficient power (80%) to detect a medium effect size of 10% improvement in PA prevalence at a 5% significance level by the intervention group relative to the control group without covariate adjustment (MOH, 2011a; Wong, Lee, James, & Jancey, 2018). To allow for 80% data completion across the two assessments due to attrition and withdrawals, at least 600 participants satisfying the selection criteria were initially recruited at baseline.

3.4.2 Recreational centres

Selection of regions

Three out of the five geographical districts in Singapore were systematically selected to represent the intervention regions by drawing names from a bag. The additional district enhanced the chance of recruiting more participants into the intervention program. The remaining two districts were allocated to the control group. This process resulted in the selection of three intervention regions (South East, Central and North West) and two control regions (North East and South West).

Selection of recreational centres

The RCs (n = 579), venues built below Singapore's public housing to promote friendship, neighbourliness and leisure activities (Wong et al., 2019), were categorised according to their location within the regions and allocated a serial number (see **Appendix J,** *Details of Study Site*s). Following the research protocol (Wong et al., 2018), a sub-sample of intervention RCs (N = 31) and control RCs (N = 30) was randomly selected by the principal investigator (PI) using a computer random number generator.

Recruitment and screening

The managers of the 61 RCs were contacted to explain the study's purpose, duration and procedures. After the phone screening, 26 (intervention N = 14, control N = 12) RCs (see **Figure 3.3**) agreed to participate in the study.

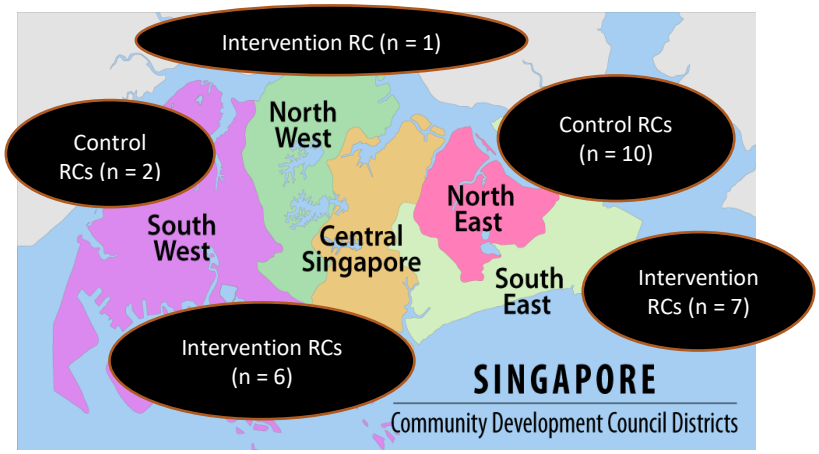
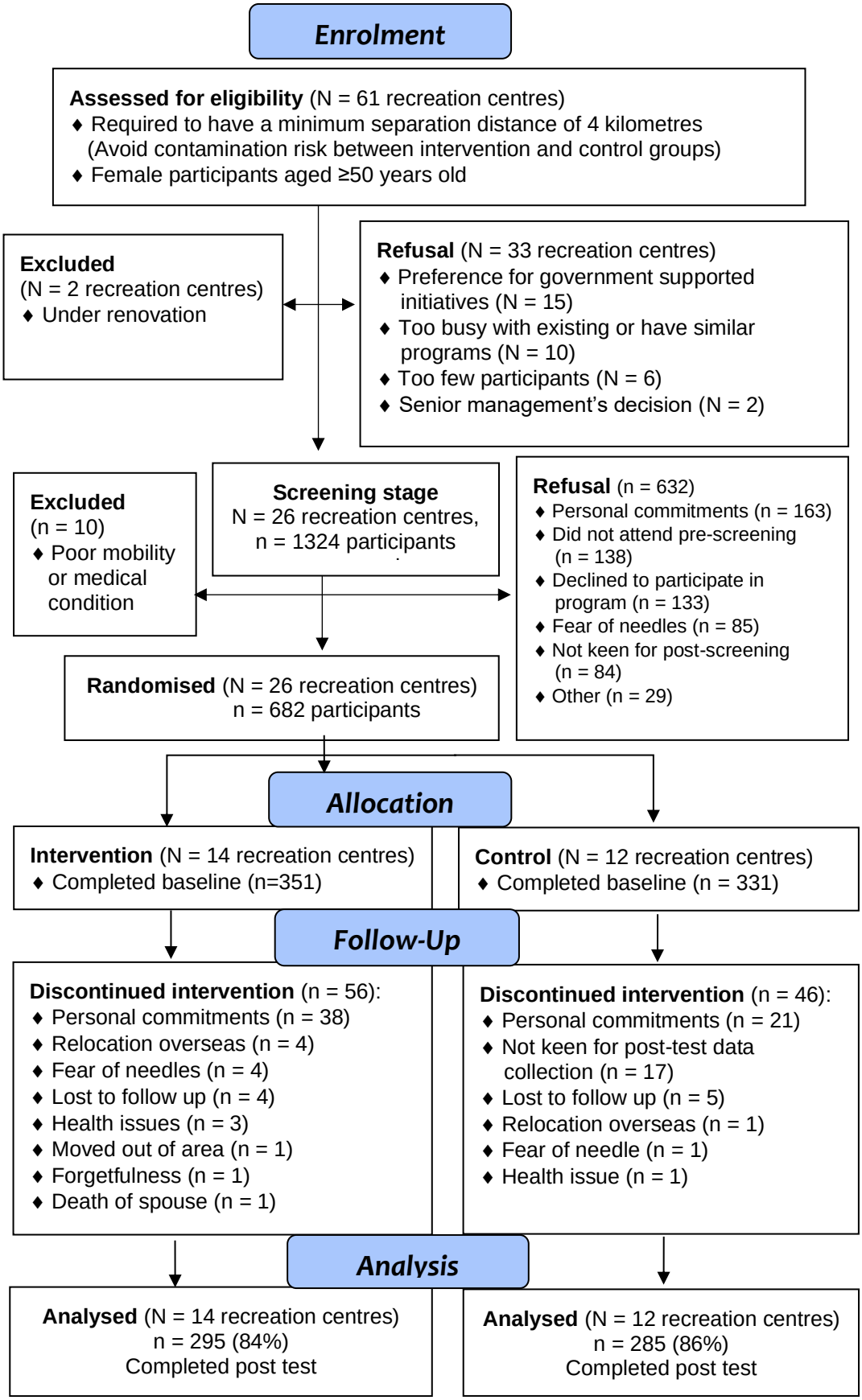


Figure 3.3 – Intervention and control recreation centres for the study
(Community Development Council Districts of Singapore, 2020)

3.4.3 Participants

Recruitment

The managers from the 26 RCs publicised the program during their centre's activities and placed the respective *SPANS Recruitment Flyers* (see **Appendix K**) on bulletin boards. Contact details of interested participants (intervention and control) were provided to the research team. Face-to-face information sessions on the SPANS were conducted by the PI for groups of interested participants.



N = Number of recreation centres
n = Number of participants

Figure 3.4 Study procedure

Screening

Participants were screened according to the selection criteria:

- Female aged ≥50 years old.
- Performed <150 minutes of self-reported weekly moderate-intensity PA.
- Absence of medical condition or poor mobility restricting their study involvement.
- Not currently enrolled in other PA and nutrition research.

Self-reported moderate PA levels were determined using the Global Physical Activity (GPAQ) Short Form (SF) (Chu et al., 2015). Participants with hyperglycaemia (blood glucose [BG] >7 mmol/L) (MOH, 2014b) and/ or hypercholesterolaemia (total cholesterol [TC] ≥6.2 mmol/L) (MOH, 2016a) were referred to their medical practitioner for follow-up and excluded from the study. Participants on any medications were recorded in the pre- and post-surveys.

Allocation to intervention and control group

A total of 682 eligible participants (intervention n = 351, control n = 331) were recruited into the study (see **Figure 3.4**). Intervention group participants received the SPANS intervention, educational resources and support from program ambassadors. The control group participants were only contacted to undertake pre- and post-test assessments and were given a falls prevention pamphlet. All participants were blinded to their intervention status. The PI and program ambassadors collecting the baseline and follow-up data were not blinded to the group allocation of the study participants.

3.5 Intervention Design

3.5.1 *Theory, Model and Motivational Interviewing*

Physical activity and dietary interventions should be guided by theories and models to support approaches in eliciting positive health behaviours. The study was underpinned by the Social Cognitive Theory (SCT) and the Socio-Ecological Model (SEM) to promote behavioural changes in older Singaporean women. Both of them are substantiated by various reviews of PA and dietary interventions to influence behavioural modifications in older adults (Golden & Earp, 2012; Young et al., 2014).

They were applied in the SPANS to improve PA and dietary changes in the target group. For more details, refer to the mapping of SCT and SEM to inform intervention strategies and methods (see **Appendix L**). Motivational interviewing (MI) techniques, which has been shown to positively motivate and support behaviour change (Cummings, Cooper, & Cassie, 2009; Low, Lee, & Samy, 2015) also guided the intervention.

Social Cognitive Theory

Albert Bandura (2004) postulates that the social and physical environments interact with an individual to shape health behaviours. Understanding these interactions may support the development of an effective intervention to promote positive health behaviours (Young et al., 2014). SCT's fundamental construct of self-efficacy concerns confidence in executing PA and nutrition behaviours (Anderson et al., 2010). Other SCT constructs, including outcome expectation, observational learning, goal-setting, social support and reinforcement, were used to inform program strategies to promote healthy behaviours in the SPANS (see **Appendix L,** *Mapping of SCT to Inform Strategies and Methods).*

Socio-Ecological Model

The SEM describes the interplay of personal and socio-environmental components on health behaviours in PA and nutrition interventions (Golden & Earp, 2012; McCormack & Shiell, 2011). Multiple factors of the SEM were applied to the SPANS (see **Appendix L,** *Mapping of SEM to Inform Strategies and Methods*).

Motivational Interviewing

Motivational Interviewing techniques focus on a person-centred style of interaction to elicit positive behavioural changes and establish rapport (Rollnick, 2010). Such techniques assisted in empowering participants to adopt PA and dietary modifications in the SPANS (see **Appendix L,** *Mapping of MI Techniques to Inform Strategies and Methods*).

3.5.2 Formative evaluation

Recruitment

The participants (n = 40) for the two focus groups were purposefully selected. They were required to meet the study's selection criteria and were recruited from the non -participating RCs. After collecting participants' signed consent forms from the centres, a convenient date and time for the discussions were set by the program ambassadors at the RCs.

Focus groups procedure

The PI facilitated the 60-minute discussion to a) assess the suitability of the SPANS program and resources (calendar, booklets and poster) (see **Appendix K**) and b) evaluate participants' understanding of the pre- and post-test questionnaire (see **Appendix M)**. A discussion schedule of open-ended *Interview Questions* (see **Appendix N**) guided the focus group discussions facilitated by the bilingual PI (English and Chinese). Participants were assured that their responses were anonymous and encouraged to provide their opinions freely. Information was recorded by the program ambassadors.

Audit of recreational centres' facilities and activities

Audits of 100 RCs' facilities and activities were undertaken at various study sites (see **Appendix O)**, followed by face-to-face interviews with 22 RC patrons to explore their views on these centres (Wong et al., 2019). Five trained research assistants were allocated to each of the Singapore regions to conduct the audits and interviews independently from March to Aug 2017. These patrons (women aged ≥50 years old), were purposefully selected, with ≥4 participants from each district. The *Audit Checklist* (see **Appendix P**) was adapted from the 'Audit of Physical Activity Resources for Seniors' (Holt, Lee, Jancey, Kerr, & Howat, 2016; Kerr et al., 2011) to inspect features of the RC facilities, activities and surrounding areas. *Interviews* with RC patrons were conducted using a structured *Interview Schedule* (see **Publication 2,** Appendix B) to explore their perception of the RCs. Descriptive statistics were used to describe characteristics of the RCs facilities and activities and patrons' demographics using the *Statistical Package for Social Sciences* (SPSS) *software version 25* (IBM Corporation, 2017). Qualitative data from the interviews were

translated, transcribed, coded and categorised into specific themes and managed by the *NVivo software version 11* (QSR International, 2017).

3.5.3 Intervention program

3.5.3.1 Program design

The design of the six-month intervention program was based on previous PA and nutrition interventions with older adults (Blackford, Jancey, Lee, James, Howat, et al., 2016; Burke, Jancey, et al., 2012; Jancey et al., 2017) including Asian PA and dietary interventions (Ohno et al., 2015; Soon, Abu Saad, Taib, Abd Rahman, & Mun, 2013; Tran et al., 2017; Yoo, Kim, & Cho, 2012). The community-based program comprised of tailored PA and nutrition sessions, resources and motivational support by trained program ambassadors. The intervention strategies aimed to educate and motivate the participants to modify their PA and dietary behaviours and improve health outcomes. Participants' goal-setting, self-monitoring and positive reinforcement were facilitated through two program ambassadors assigned to each RC.

3.5.3.2 Program ambassadors' training

The trained program ambassadors (13 final-year undergraduate students in nutrition, sports and wellness, two nutritionists and a fitness instructor) were screened for suitability. They were required to attend a full day of intensive training conducted by the PI, be bilingual, have expertise in PA and nutrition and an interest in older adults. During the training, the program ambassadors were informed of the program's aim, objectives, timeline, ethical process, protocols for collecting, recording and managing data (anthropometric, BP and accelerometry measurements) and the principles of MI. Program ambassadors received the following intervention materials (see **Appendix G-R)**:

- Participant information sheet and consent form, data management plan and details of study sites.
- SPAN's recruitment flyers, health calendar, booklets and sample incentives
- Accelerometer instructions
- MI training resources
- Pre- and post-test questionnaire
- Notebook to document study observations and record participants' feedback.

3.5.3.3 Program resources

Throughout the intervention, participants received bilingual resources that provided information on PA, diet and prevention of chronic diseases. These resources (see **Appendix K)** designed by the Health Promotion Board (HPB) imparted simple, attractive and culturally suitable messages for a Singaporean context (HPB, 2015a, 2015b).

a) Health calendar

Participants recorded their PA and dietary goals using the *health calendar*. The calendar contained a series of photos and written instructions for exercises and healthy recipes with nutritional advice. This calendar enabled participants to monitor their goals and activities as well as write down program challenges, barriers and motivators. A directory of health agencies and web links to dietary and PA resources was provided.

b) Physical activity booklet

The *Active for Life* booklet explained PA benefits, principles and safety tips and the importance of staying hydrated. It was developed using the *National PA Guidelines: Summary Guide for Professionals* (HPB, 2015a). Illustrations of activity planners encouraged participants to incorporate a variety of aerobic, muscle-strengthening and flexibility activities.

c) Nutrition guidebook

The *Recipe for Healthy Ageing* guidebook was created using the Singapore Dietary Guidelines for Healthy Ageing (HPB, 2015b). It contained advice on nutrient-dense foods, daily nutrient requirements and healthier meal options when dining out and shopping for healthier choice symbol products. The accompanying *poster* recommended easy to follow tips on 'My Healthy Plate' guidelines. Participants were encouraged to display the poster in home dining areas to reinforce healthy eating habits.

d) Recipe booklet

Colourful and visually attractive food photographs in the *Recipe for Healthy Ageing* recipe booklet promoted the preparation of nourishing meals, arranged according to

nutrition themes, such as high-protein, calcium-rich, low-salt, high-fibre and wholegrains. Healthy eating tips guided participants to select ingredients to cook nutritious meals.

e) Blood pressure booklet

Information on high blood pressure (BP), associated risk factors and ways to prevent and manage hypertension were explained in the *Your Guide to Lowering BP* booklet, which also contained a section on frequently asked questions.

f) Cholesterol booklet

The *Cholesterol Matters to Everyone* booklet covered desirable lipid levels, health risks associated with high cholesterol levels, effects of fat types on diet, management tips, commonly asked questions and multi-ethnic recipes.

g) Diabetes booklet

The *Keeping My Blood Sugar Levels Healthy* booklet introduced risk factors of diabetes, its signs and symptoms, effects of sugar on the body and PA and dietary advice to reduce BG levels.

3.5.3.4 Program delivery

Participants were divided into groups (n = 20–30) to attend face-to-face PA sessions and nutrition workshops at their respective RCs, early morning (8:00 a.m.) or late afternoon (5:00 p.m.) throughout the 24 weeks. A list of program strategies is included below with details of the activities and resources outlined in the *Components of the Intervention Program* (see **Appendix Q**):

- *12 PA classes* were conducted by a certified fitness instructor comprising a brief education session of 15 minutes followed by 45 minutes of PA session every 2 weeks. The PA lesson plans were informed by Singapore's national PA guidelines (HPB, 2015a).
- *3 nutrition workshops* were implemented by two qualified nutritionists for an hour bimonthly. The workshop lesson plans were guided by the Singaporean Dietary Guidelines for Healthy Ageing (HPB, 2019c).
- *3 dietary phone counselling sessions* guided by MI techniques were carried out by the nutritionists for approximately 60 minutes bimonthly.

- 6 *mobile text messaging* via the WhatsApp platform was used to share information, co-ordinate feedback and answer questions every month. Phone calls were also made monthly by the program ambassadors to follow up on participants' progress and encourage PA and dietary changes.

3.6 Data management plan

A *Data Management Plan* (see **Appendix R**) was documented to ensure that data were safely collected, stored and shared among the research team. A participant identity list, including the participants' name and identification numbers, was kept separate from the primary research data. All data were de-identified using the identification number to enable anonymous tracking. Only the PI had access to the identifiers that linked study data to the participants. Hard copies of all questionnaires and health reports were stored in a locked cabinet, made accessible only to the research staff. Data were stored on a password-protected university network drive. All data will be retained for seven years after the completion of the study.

3.7 Outcome measures

3.7.1 Demographics

The *pre- and post-test questionnaire* (see **Appendix M)** was administered face-to-face by the program ambassadors to record the participant's demographics and lifestyle characteristics including primary and secondary outcome variables.
Under the supervision of the PI, program ambassadors coordinated the baseline and post-test (six-month) assessments. **Table 3.2** displays variables with corresponding instruments assessed at the two time points.

Table 3.2 Summary of variables and measuring instruments

Variables	Measuring instruments
Demographics (age, ethnicity, education level, marital status and housing type) and lifestyle characteristics (health conditions and medications)	Self-reported pre- and post-test questionnaire

Primary outcomes	
Self-reported physical activity behaviours (moderate, vigorous, total, walking and cycling) and sedentary behaviour (sitting time)	Global Physical Activity Questionnaire-Short Form from the STEPwise approach to Surveillance (Chu et al., 2015)
Objective measures of physical activity behaviours (moderate, vigorous, total) and sedentary behaviour (sitting time)	ActiGraph GTX3 accelerometers (Chu et al., 2017)
Self-reported dietary behaviours (intake of fruit, vegetables, wholegrains, salt and salty sauces, fatty food and sugary beverages)	Modified dietary behaviour questionnaire from the STEPwise approach to Surveillance (Riley et al., 2016)
Fasting blood glucose and lipid profile (total cholesterol, low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol, non-high-density lipoprotein-cholesterol and triglyceride concentrations)	Fasting blood samples (Chen et al., 2010; Giacco et al., 2013; Moriyama & Takahashi, 2016; Wang et al., 2017)
Secondary outcomes	
Systolic and diastolic blood pressure	Omron electronic blood pressure monitor (HEM 7203) (Muntner et al., 2019; Seow, Subramaniam, Abdin, Vaingankar, & Chong, 2015)
Anthropometric measurements (Weight, body mass index, waist circumference, hip circumference waist-hip ratio and body fat percentage)	Calibrated weighing machines, portable stadiometer, calculators, tape measures and Endo body fat composition analysers E-DBS908 (Bi, Loo, & Henry, 2018; Blackford, Jancey, Lee, James, Howat, Hills, et al., 2015; Ma et al., 2013; Misra & Dhurandhar, 2019; Nakade et al., 2012; Yi-Chun et al., 2013)
Self-reported health-related quality of life indicators	Short Form 8 questionnaire (Lang et al., 2018)

3.7.2 Physical activity and sedentary behaviour

Self-reported measures

The GPAQ-SF was taken from the STEPwise approach to Surveillance (STEPS) developed by the World Health Organization (WHO) to monitor PA and sedentary behaviour (SB) (WHO, 2019c). It consists of 16 questions and is available in the English and Chinese languages (WHO, 2019c). The instrument displayed acceptable to excellent reliability and was validated among adults in over 20 countries, mainly in Asia and Europe (Herrmann et al., 2013; Keating et al., 2019). It assesses PA domains such as walking and cycling PA, leisure-time PA and SB (sitting time), which are central for determining the effectiveness of behavioural change interventions (Strath et al., 2013). Data were collected on PA components such as frequency (days per week), duration (minutes per day) and intensity (moderate to vigorous).

Objective physical activity measures

Similar to self-reported measures, accelerometers measured PA and SB (frequency, duration and intensity) (Chu et al., 2017). Accelerometers are small portable devices which produce an electric current to detect body acceleration (Hills et al., 2014) with high accuracy and reliability for PA assessment (Chomistek et al., 2017).
Program ambassadors were responsible for distributing the instruction sheet, explaining the management of *ActiGraph GXT3* accelerometers (Florida, USA) and fitting the devices to the intervention participants. A convenience sub-sample of intervention participants who agreed to wear the accelerometers was recruited. The accelerometers were aligned with the midaxillary line on the participants' right hip bone. Participants were required to wear the device for ≥4 consecutive days of ten hours daily during waking hours (excluding sleeping time and water-based activities) (Aguilar-Farías, Brown, & Peeters, 2014). Participants were reminded to wear the devices correctly and to return them at the PA sessions when they had completed the wearing period during baseline and post-intervention. When program ambassadors received the devices, they downloaded the stored data into the *ActiLife version 6.13.3 software* (ActiGraph, 2016) using 10-second epochs.

3.7.3 Dietary behaviour

The *dietary questionnaire* was adapted from the STEPS developed by WHO as a standardised, inexpensive tool to assess food consumption patterns worldwide (Riley et al., 2016; WHO, 2019c). It was utilised in Singapore to evaluate self-reported dietary intakes of fruit, vegetables, wholegrains, salt, fat and sugar for NCD prevention (Riley et al., 2016; WHO, 2019c). Intake of wholegrains has been an emerging dietary practice of concern as only a marginal increase (14% to 17%) was observed among Singaporeans adults from 2010 to 2018 (HPB, 2018). Therefore, an additional question on the consumption of wholegrains was added to the questionnaire to assess this dietary practice. Moreover, some questions were elaborated further in the Chinese language to ensure its suitability in the Singaporean context. For instance, the question on 'sugary beverages in the diet' provided specific examples of local drinks such as sweetened tea and coffee, packeted herbal drinks and malted drinks to elicit accurate responses.

3.7.4 Fasting blood glucose and lipid profiles

Participants fasted overnight for ten hours before the collection of blood from their antecubital vein into the appropriate serum and plasma vacuum collection tubes by phlebotomists at community screening sites. The blood samples were stored at 4–8°C in iceboxes and then transported to the Quest laboratory within eight hours for analysis using routine automated procedures. The following tests were performed on the collected samples.

- *Total cholesterol, triglyceride, high-density lipoprotein-cholesterol* and *fasting blood glucose* were measured using an Architect ci16200 analyser and determined by the enzyme-based colorimetric reagents (Illinois, USA).
- *Low-density lipoprotein-cholesterol* was determined by the modified Friedewald equation (Chen et al., 2010).
- *Non-high-density lipoprotein-cholesterol* was calculated by subtracting the concentration of high-density lipoprotein-cholesterol from total cholesterol concentration.

3.7.5 Anthropometric measurements

Trained program ambassadors conducted the following measurements while the participant stood upright, following a standardised protocol (Bi et al., 2018). These measurements were performed according to previous PA and dietary interventions for older adults (Blackford, Jancey, Lee, James, Waddell, et al., 2016) and the International Society for the Advancement of Kinanthropometry guidelines (Marfell-Jones, Stewart, & Olds, 2006).

- *Weight* recorded to the nearest 0.01 kg (without shoes) using a calibrated electronic scale, while a stadiometer measured the *height* (barefooted) to the nearest 0.1 cm.
- *Body mass index* measured as weight (kg) divided by height $(m)^2$.
- *Body fat percentage* measured by an Endo body fat composition analyser E-DBS908 **(**without shoes and socks).
- *Waist circumference* measured using a plastic measuring tape midway between the lowest rib margin and the iliac crest and recorded to the nearest 0.5 cm.
- *Waist-hip ratio* calculated by waist circumference (cm) divided by hip circumference (cm).
- *Hip circumference* was measured to the nearest 0.5 cm at the widest part at the level of the symphysis pubis and gluteus maximus.

3.7.6 Systolic and diastolic blood pressure

Blood pressure measurements were taken by trained program ambassadors following standard protocols (Muntner et al., 2019). Participants abstained from drinking alcohol or caffeinated beverages, smoking or exercising for ≥30 minutes before the measurement procedures. They were seated with legs uncrossed and left elbow raised to the heart level. The mean averages of systolic and diastolic BP were determined after three consecutive measurements of a one-minute interval using an Omron HEM 7203 automatic BP monitor with an appropriately sized cuff on the left arm (Seow et al., 2015).

3.7.7 Health-related quality of life indicators

The self-reported health-related quality of life (HR-QOL) SF *8* examined the perception of physical, psychological and social domains of health (Lang et al., 2018). This tool has excellent internal reliability and known-group validity among 10,885 Chinese adults (Lang et al., 2018). It was applied in this study due to its brevity, high reliability and validity in an Asian context.

3.7.8 Analysis of outcome measures

Statistical analyses were performed using *SPSS software version 25* (IBM Corporation, 2017) with a statistical significance level set at 0.05. No outcome measures underwent normal transformations before analysis. Two levels of data screening were conducted to ensure accuracy in data entry. The research assistant keyed in the coded responses into the software and then checked against the hard copies of the questionnaires to ensure data accuracy. At the second level, data were verified and cross-checked by the PI.

Univariate analyses

Descriptive statistics were first applied to summarise participants' demographics and lifestyle characteristics. For self-reported PA data, the GPAQ-SF quantified these activity levels using the metabolic equivalent of task (MET), where one MET is " the energy cost of sitting quietly, equivalent to a caloric consumption of 1 kcal/kg/hour" (Win et al., 2015, p. 3). Accounting for the different intensities of the PA levels, self-reported weekly minutes are multiplied by 8 METs for vigorous PA, 4 METs for moderate PA and walking and cycling PA. The addition of these PA levels gives the total PA levels in MET-minutes (World Health Organization, 2019d).

For the accelerometry data from a subgroup of participants, data with <4 days of ten hours daily wear time were excluded from the analysis using the algorithm of Troiano (Knaier, Höchsmann, Infanger, Hinrichs, & Schmidt-Trucksäss, 2019). This exclusion was based on ≥60 consecutive minutes of zero activity counts with an allowance of up to two consecutive minutes of counts from 1–100 (Knaier et al., 2019). The Freedson cut-off points for adults were selected to determine SB (< 100

counts per minute [CPM]), moderate-intensity PA (1952-5724 CPM) and vigorous-intensity PA (5725-9498 CPM) (Do et al., 2019).

Vigorous PA was recoded into binary form to specify the participation status (no=0, yes=1) as the majority of participants did not engage in such activity. Fruit and vegetable consumption was classified as 'frequent intake' (no=0, yes=1) if ≥2 servings were eaten daily, whereas salt and salty sauce and wholegrain consumption were classified as 'frequent intake' if taken ≥1 per week. Sugary beverage and fatty food intake were classified as 'frequent intake' if taken ≥3 times per week.

Outcome variables between the two groups at baseline and the six-month post-test were compared using:

- *Independent t-tests and paired t-tests* for continuous outcomes (self-reported PA, SB and accelerometry data, fasting BG and lipid profiles, anthropometric measurements and BP).
- *Mann-Whitney U test and Wilcoxon Signed-Rank test* were also applied to continuous variables with skewed distributions.
- *Chi-square tests* for dichotomous and categorical outcomes (vigorous PA, dietary behaviours and HR-QOL indicators).

Multivariable analyses

To accommodate the correlation of observations due to the clustering of individuals within the centres, generalised estimating equations (GEE) *models* with exchangeable correlation structure were used to assess the differences in outcome variables between the two groups over time. The purpose of performing GEE models was to confirm any apparent association from the univariate analysis while accounting for potential confounders (age, ethnicity, education, marital status, housing type, health conditions and medication usage), together with the clustering effect of observations.

These GEE models included:

- *Normal GEE models with identify link* were applied to normally distributed continuous outcome variables.

- *Gamma GEE models with log link* were applied to skewed continuous outcome variables.
- *Logistic GEE models* were used to analyse binary and categorical outcome variables.

3.8 Process evaluation

Process evaluation is an essential criterion in documenting a program's quality, fidelity and effectiveness (Bauman & Nutbeam, 2013). A large body of evidence has justified its application in determining effective program strategies to recruit and retain participants (Blackford et al., 2017), acceptability and appropriateness of resources (Burke, Jancey, et al., 2013; Jancey et al., 2018) and identification of reasons for program completion and non-completion (Jancey et al., 2018; Tran, Jancey, et al., 2017).

3.8.1 *Procedure*

A process evaluation framework developed by Saunders et al. (2005) was adapted to assess the implementation of the SPANS. The following components of the SPANS were assessed as part of the process evaluation: participants (recruitment and reach), program strategies (fidelity, completeness, exposure and satisfaction) and contextual factors affecting intervention. Quantitative and qualitative data were collected by the program ambassadors using the following instruments at scheduled times throughout and post-intervention at the RCs:

- S*emi-Structured Exit Interviews* (see **Appendix S**).
- *Self-Administered Evaluation Form* (see **Appendix T**).
- *Program Ambassadors' Documentation*.

RC participants who were not participating in the SPANS were purposefully selected to pilot test the *Exit interviews* (n = 5) and *Evaluation form* (n = 10) Two program ambassadors explained the purpose of the evaluation form and exit interviews before obtaining informed consent to trial them.

3.8.2 *Instruments*

Participants were contacted by phone to ask if they were willing to participate in the exit interviews.

- *Exit interviews* were adapted and translated from previous process evaluation tools used in PA and nutrition studies with older adults (Blackford et al., 2017; Jancey et al., 2018; Tran, Jancey, et al., 2017). Twenty-five participants (13 completers, 12 non-completers) were purposefully selected to participate in the exit interviews. Program completers were defined as 'participants who attended at least half of all the program sessions and completed pre- and post-test assessment. After verbal consent was obtained, the interviews were conducted in English or Mandarin via phone by two program ambassadors. The completers commented on reasons for program participation, perceptions of program strategies, attitudes and behavioural changes and suggestions for program motivators and improvements. Whilst, the non-completers were asked about their period of program engagement, reasons for program withdrawal, program barriers and motivators and recommendations for program improvements. For both interviews, program ambassadors' support and guidance were ranked using a 10-point Likert scale (1=not good to 10=very good).
- *Evaluation form* consisted of a 5-point Likert scale (1=poor to 5=excellent) for intervention participants to rank program components and program ambassadors. Open-ended questions were included for suggestions on program improvements, future health activities and topics.
- *Program ambassadors' documentation* collected feedback relating to the program strategies and identified any issues that might impact attendance and acceptability of program strategies, together with recommendations for improvements. Attendance at all sessions was documented. Reasons for participants' absence at any session were recorded after the program ambassadors conducted the follow-up calls.

3.8.3 *Analysis of process evaluation data*

Quantitative analysis

Responses to the Likert scale ratings from the evaluation form were recoded into dichotomous variables (unsatisfactory [1–2] and satisfactory [3–5]) and percentages were derived using *SPSS software version 25* (IBM Corporation, 2017). Mean scores for the Likert scale rating (1–10) from the exit interviews for program ambassadors were also computed.

Qualitative analysis

All qualitative data were translated and transcribed verbatim two weeks after the interviews. Data were collated to create key themes using an inductive approach (Vaismoradi, Turunen, & Bondas, 2013). Thematic analysis of the data was reviewed and coded by the research team to identify common concepts (Nowell, Norris, White, & Moules, 2017). Direct quotes from de-identified participants supported text analysis. The *NVivo software version 11* was used to manage the transcripts and data (QSR International, 2017). Full details of the process evaluation are presented elsewhere (see **Publication 3,** Appendix B).

Chapter 4
Results

This chapter presents a brief overview of the research findings on the Singapore Physical Activity and Nutrition Study. These summaries are related to the results for the following:

- Audit of recreational centres' (RC) facilities and activities.
- Process evaluation.
- Changes in outcome measurements.

More details are described in the following three publications (see **Appendix B,** *List of Publications*) which addressed the remaining research objectives 2 to 5. The translation of research findings provides practical insights to policymakers and relevant stakeholders in designing future physical activity (PA) and dietary behavioural change interventions among at risk Singaporean women.

4.1 Audit of recreational centres' facilities and activities

Publication 2:

Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore

It addresses objective 2:

- Examine the facilities and activities of RCs to support PA and dietary practices for the target group.

Citation:

Wong, E. Y.-S., Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational centres' facilities and activities to support healthy ageing in Singapore. *International Journal of Environmental Research and Public Health,* 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343

4.1.1. Summary of audit results

The audit study aimed to examine the physical environment (facilities and activities) of the RCs and female patrons' (≥50 years old) perception of the RC facilities and activities (Wong et al., 2019). This study identifies motivators, constraints and visitation patterns of the RC setting to inform the SPANS intervention.

Most of the 100 audited RCs (80%) received funding from the Singaporean Health Promotion Board and participated in government health initiatives over 14 months. The majority of the centres (87%) offered more PA classes (mean 8 classes, per month) compared to nutrition (60%) and social activities (37%) (mean 1 class, per month). The percentage of RCs having exterior PA-related features ranged from bike paths (41%), basketball/badminton courts (60%), bicycle racks (73%) and exercise/fitness stations (80%) to nearby parks and gardens (83%). Due to the small average RC size of 105 m^2 (40% of a tennis court), a minority of RCs have dedicated fitness space (26%) and fitness equipment (14%). In comparison, fewer than half of them have exterior and interior nutrition-related features such as vending machines with healthy food and drink items (33%), vegetable, fruit and spice gardens (36%), kitchen (36%) and cooking utensils (46%). Unused grassy areas outside RC premises could be targeted to incorporate community gardening. Revamping of RCs' facilities (indoors and outdoors) could include kitchen studios to accommodate more culinary activities.

During the face-to-face interviews, most of the 22 participants (mean age 65 years) commented that RCs were convenient venues in which to interact with their neighbours and family members. They commented on the sociability and approachability of RC managers as reasons for motivating them to stay fit and eat well. Suggestions for improving RC engagement included the addition of extrinsic (monetary incentives and nutritious refreshments) and intrinsic (enjoyable experiences and community belonging) motivators to promote RC utilisation. Participants also recommended the need for less strenuous classes, provision of flexible schedules and outdoor park activities to increase their PA levels. Other noteworthy suggestions included enlarging the size of the centres, providing age-friendly facilities and aesthetically pleasing surroundings to increase program adherence and improve social connectedness. Regular consultations between RC

managers and participants are imperative to develop relevant programs and policy initiatives. In turn, findings from the audit may enhance RCs' facilities and activities targeted at community dwelling older adults to facilitate their regular PA and healthy eating practices.

More details are provided in publication 2 below that addresses objective 2.

Publication 2

Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore

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Abstract: Objective: This study examined the physical and social environment (facilities and activities) of Singapore's Recreational Centres (RCs) and female patrons' (>50 years) perception of the RC facilities and activities. Materials and Methods: A total of 100 RCs were audited, and 22 face-to-face interviews were undertaken. Results: Physical activity classes were the main activity offered (mean = eight classes per month), with walking (29.8%) and aerobics sessions (17.5%) being the most frequent. Nutrition classes and social activities were offered less often (mean = one class per month). The activities were well received by patrons, offering opportunities to interact while participating in physical activity and nutrition classes. However, the need for staff training, consideration of patron's abilities and the desire to engage in alternative activities were expressed. Conclusion: Overall, RCs' facilities and activities were well liked by the patrons but opportunities for improvements were identified. Regular reviews of facilities and activities through consultation with the RC patrons and managers are needed to ensure that the facilities and activities remain relevant and practical to the patrons. This will help to support active lifestyles and healthy eating practices among older adults residing within the community.

Keywords: age-friendly; facilities; healthy eating; health behaviour; health promotion; lifestyle; physical activity; recreational centres

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1. Introduction

Inadequate levels of physical activity (PA) and poor dietary behaviours are key modifiable risk factors for non-communicable diseases (NCDs) [1]. These risk factors contribute to two in five deaths worldwide and 30% of the global NCD burden [2]. Studies worldwide have demonstrated that community settings, such as Recreational Centres (RCs), are promising environments to support PA and dietary behaviours and enable individuals to adopt and sustain a healthy lifestyle [3–6]. The local environment surrounding the RCs can potentially provide opportunities to support PA (traffic-free and safe walking routes) or inhibit PA (poor lighting and uneven walkways) [7–9]. In addition, the environment can also encourage healthy eating (communal fruit and vegetables garden) or inhibit healthy eating (presence of unhealthy foods in vending machines) [10,11]. Recent systematic reviews have reported that adults are more physically active when living in close proximity to recreational destinations such as health services, food outlets, parks and shops [12–14], while environments with connected streets, good public transport and ease of pedestrian crossing are positively related to increased PA [4,7,12]. Interventions embedded in the community have also been found to increase social opportunities, strengthen social networks among friends and family members that facilitate healthy eating and active urban living practices [15,16].

Despite the strong evidence that the RC environment (physical and social) may support PA and dietary behaviours [3–6,17], limited research has been undertaken in the over-50 group in Asian communities [18]. Most studies reporting on the effectiveness of community-based lifestyle programs

originated from Europe, Canada, USA and Australia. Based on the findings from these studies, further research is recommended to explore the influences (social contact, environmental opportunities and program enjoyment) for effective lifestyle programs, highlighting the need for research on Asian communities and especially the unique RC setting in Singapore.

As Singaporeans age, they become increasingly sedentary. Results from the National Health Survey 2010 revealed that the majority (63%) of the 50–69 year olds participated in no leisure time PA, while also consuming high amounts of low-nutrient, energy-dense meals [19,20]. A high proportion of older Singaporean adults aged over 50 years had pre-obesity (34%), high levels of abdominal fatness (32%) and impaired glucose tolerance (22%), with higher rates occurring among older women [20]. These behavioural and metabolic risk factors increase their risk of NCDs [21]. Cardiovascular diseases, cancer and diabetes account for 64% of the disease burden in Singapore [22], as one-quarter of adults aged over 65 have at least one NCD [23]. The Singapore government has invested significantly in the management of chronic diseases such as cardiovascular diseases (US $8.2 billion) [24] and diabetes (US $0.7 billion) annually [25].

Considering the high cost of NCD management, the high prevalence of metabolic risk factors and unhealthy lifestyle practices among older Singaporean adults [26], there is an urgency to examine the physical and social environments to develop effective community-based programs to enhance health behaviours. Multi-component strategies in health programs that include group education, PA classes and dietary counselling sessions have resulted in improvements in physiological outcomes [27–29]. Additionally, available evidence indicates that there is some cost-effectiveness in community health programs [30]. Studies undertaken in Western developed countries have reported achieving lower cost per quality adjusted life years (QALYs) through health programs conducted for a longer duration [31]. These programs focused on different NCDs, such as diabetes and cardiovascular diseases, and ranged from US$1413 to US$7301 per QALY gained for adults, depending on the extent, duration and resources of the program [31–35]. Singapore's unique RCs may provide an opportunity to promote cost-effective lifestyle programs to support health-enhancing behaviours.

Singapore's RCs are communal spaces built in the 1970s to support a sense of community among residents who had moved out of their rural village into these urban Housing Development Board estates [36]. These RCs were built below the dense high-rise public housing, where more than 80% of Singaporeans now reside [37]. These public communal spaces serve as a venue for residents to undertake activities, interact and foster community cohesiveness [38]. There are 579 RCs located across the five major districts in Singapore (Central (n = 164), North-East (n = 140), South-West (n = 115), North-West (n = 106) and South-East (n = 54)), each with a similar socioeconomic status [39]. These RCs are staffed with managers who collaborate with the Health Promotion Board (HPB) to promote health and wellness activities [40]. The HPB has been tasked with the vision of building "a nation of healthy people" by encouraging health-enhancing behaviours and preventing illness, disability and premature death [41]. The majority of patrons who frequent these RCs are women aged 50 years and over [42,43], providing a local community environment to support positive changes in PA and dietary behaviours for this 'at-risk' group [44], yet little evidence has been documented [4,45], especially how the RCs can engage and empower these older Singaporean women in healthy lifestyles.

The present study provided the first report to address this gap in the literature. It aimed to examine the physical environment (facilities and activities) of the RCs and female patrons' (>50 years) perception of the RC facilities and activities. The study was underpinned by the social-ecological model and Social Cognitive Theory (SCT) due to the interplay between various health determinants. The model aids in understanding the complexity of health behaviours [46,47], emphasizing the multiple levels of influences (individual, interpersonal, community) that shape health behaviours within the environment [48]. The principles of the model are consistent with SCT concepts, which recognise that people are not only driven by inner forces or shaped by external influences [49], but also by human behaviour, cognition, personal factors and the environment [50]. Both quantitative (assessment of the physical environment) and qualitative (interviews with RC patrons to assess their experiences) data were collected to identify activities and facilities offered by the RCs, and the patrons' perceptions of these activities and facilities. Such information will assist our understanding

of these facilities and their usage, which is important for the development of strategies for cost-effective programs to increase engagement with RCs.

2. Materials and Methods

2.1. Recreational Centre Recruitment

Of the 579 RCs located across the five major Singapore districts (Central, South West, North West, South East and North East), 121 were randomly selected using an online computer random number generator (see Table 1). The RC managers were contacted to explain the purpose and scope of the study. Among them, 100 managers agreed to participate. They were informed of their rights and that the audit would be kept strictly confidential and non-identifiable. A suitable time was then organised for one of the five trained research assistants (qualified nutritionists or certified fitness instructors) to visit the RC, discuss the centre's profile and undertake the audit.

Table 1. Samples of Recreational Centres (RCs) from five Singapore districts.

District	No. of RCs in District	No. of RCs Audited
Central	164	20 (12%)
North East	140	26 (19%)
South West	115	24 (21%)
North West	106	17 (16%)
South East	54	13 (24%)
TOTAL	579	100 (17%)

The standardised training of the research assistants was conducted by the principal investigator (PI; first author). They received detailed written instructions on the audit tool usage and an assessment manual. The PI further demonstrated use of the audit tool and explained the interview schedule. This was then followed by a feedback session to clarify any issues. Thereafter, research assistants conducted the audits and interviews independently. Random inspections were made to ensure that the audits and interviews were conducted properly. Permission to conduct the audit was sought from the RC managers before proceeding with the systematic observation, which was performed inside the RC premises and the surrounding area and took approximately 90 minutes to complete. Informed consent was obtained from each participant before the face-to-face interview. The research protocol was approved by Curtin University Human Research Ethics Committee (approval number: HRE2016-0366) and registered on the Australian and New Zealand Clinical Trials Registry (trial no: ACTRN12617001022358).

2.2. Audit Instrument

The 'Audit of Physical Activity Resources for Seniors' (APARS) is designed to objectively assess features of the building and surrounding areas as well as its facilities and activities. It has high inter-rater reliability, with some evidence of construct validity in assessing health-related resources in the environment [51], and has been previously used by our research team [52]. Older adults aged 50–65 years are frequent users of the RCs [42,43]. Therefore, the APARS tool was considered suitable for this assessment. The audit was adapted for the Singaporean context to identify facilities and activities (PA, nutrition and social) provided by the RCs. The audit tool assessed the presence of facilities, i.e., 'Exterior PA facilities', 'Inside PA and nutrition facilities', 'aesthetics', i.e., 'Exterior environmental features' as well as 'Inside social activities'. RC health activities were classified as 'PA activities', 'social activities' and 'nutrition activities'. In addition, the profile of each centre was also constructed by gathering data on their characteristics and patrons as provided by the RC managers (see Table 2).

Table 2. Characteristics of Recreational Centres (n = 100).

Patrons	
Age: mean (SD), years	60 (10.3)
Female (%)	82%
No. of patrons per class: mean (SD)	30 (19)
Recreational Centres	
Building area: mean (SD), m^2	104.62 (1.92)
Involved in HPB initiatives (%)	80%
Duration of HPB involvement: mean (SD), months	14 (17.1)
Government funding for patron activities (%)	80%

HPB—Health Promotion Board; SD—standard deviation.

2.3. Face-to-Face Interview Recruitment

From the 100 audited RCs, 22 RC patrons (at least four participants from each district) were purposefully selected to participate in the interviews. All participants selected were women aged 50 years and over who were currently attending the RCs and residing within the respective neighbourhood. These participants were approached and consecutively recruited at the RCs. After obtaining their informed consent, interviews of approximately 30 minutes duration were conducted in a quiet private location outside the RC.

2.4. Interview Schedule

An interview schedule was developed (see Appendix A) to explore participants' perception of facilities and activities offered at the RCs. The interview asked what participants liked about the facilities and activities, what they did not like, and how these could be improved. Interviews were conducted by the trained research assistants in the most suitable language, which included English, Mandarin and other Chinese dialects.

2.5. Data Analysis

Descriptive statistics were used to profile the characteristics of the RCs and demographics of the participants, performed using the Statistical Package for Social Science version 25 [53]. Qualitative data from the interviews were translated from Mandarin or other Chinese dialects to English and transcribed within two weeks after interview. An inductive approach was adopted to analyse the data in order to identify emerging themes [54]. Transcribed data were coded by the PI to form common categories, supported by direct quotes from the de-identified participants. Transcripts and qualitative data analysis were managed using the NVivo software version 11 [55].

3. Results

3.1. Profile and Audit of RC Facilities and Activities

The mean age of the RC attendees was 60 years and predominantly female (82%). The average building size of the RCs was 104.62 square metres (approximately 40% the size of a tennis court), and 80% of the RC managers had been involved in HPB initiatives for approximately 14 months. Eighty percent of these RCs received government funding for activities (see Table 2).

3.2. RC Facilities and Activities

As shown in Table 3, most RCs were located close to parks and gardens (83%), grassy areas (72%), had access to bicycle racks (73%) and coffee corners with benches (58%). Outside PA facilities included exercise/fitness stations (80%), basketball/badminton courts (60%) and bike paths (41%). Facilities inside the RCs included kitchen (36%), fitness space (26%) and nutrition and PA hard copy resources (41%). Nearby amenities included a coffee shop/food court (98%), medical/dental clinic (95%), bus stop and train station (94%), supermarket/wet market (92%), convenient store (92%), gym

and community centre (84%), pharmacy (65%) and physiotherapist clinic (15%). Most centres (87% offered PA classes, fewer offered nutrition classes (60%) and social activities (37%). On averag approximately eight PA classes were held per month, with walking (29.8%) and aerobics sessior (17.5%) being the most frequent activities, whereas only one nutrition class or social activity wa offered per month.

Table 3. Facilities and activities at Recreational Centres (n = 100).

Exterior Environmental Features	
Presence of parks and gardens (within 400 m)	83%
Bicycle racks	73%
> 1 grassy area (> 6m x 6m)	72%
Coffee corner with benches	58%
Vegetable/fruit/spice garden	36%
Vending machines with healthy foods/drinks	33%
No obstruction on path to centre	97%
Adequate footpaths to centre	94%
≥ 1 exterior light outside centre	80%
Exterior Physical Activity Facilities	
Exercise/fitness stations	80%
Basketball/badminton courts	60%
Bike paths	41%
Inside Nutrition and Physical Activity Facilities	
Washing basin for food preparation	80%
Utensil/Stove/Wok/Induction cooker/Oven	46%
Health booklets or recipe handouts (PA and nutrition)	41%
Kitchen	36%
Fitness space	26%
Weights/resistance equipment	14%
Inside Social Facilities	
Open social lounge or living room area with television	79%
Projector	71%
Board and card games	55%
Dining room	35%
Library	27%
Interactive video games	8%
Nearby Amenities (< 400 m)	
Coffee shop/Food court	98%
Medical/dental clinic	95%
Bus stop and train station	94%
Supermarket/Wet market	92%
Convenient store	92%
Gym/Community centre	84%
Pharmacy	65%
Physiotherapist clinic	15%
Health Activities	
PA classes: mean (SD) per month	7.87(8)
No. of RCs offering PA classes (%)	87%
Walking	29.8%
Aerobics	17.5%
Qigong	16.2%
Others (ball games, flexibility, martial arts, piloxing and yoga)	7.5%
Dance	7.0%
Tai chi	7.0%
Resistance training (resistance band)	5.0%
Nutrition classes: mean (SD) per month	1 (1.15)
No. of RCs offering nutrition classes (%)	60%
Cooking demonstrations	75.8%
Nutrition talks	24.2%
Social activities: mean (SD) per month	1 (3.19)
No. of RCs offering social activities (%)	37%
Mahjong	38.0%

Rummy O	33.3%
Bingo	28.6%

SD—standard deviation; PA—physical activity; Qigong—a holistic system of coordinated body posture and movement, breathing, and meditation; Mahjong—a tile-based game developed in China. It is commonly played by four players and is a game of skill, strategy and calculation; Piloxing—a system of exercise combining elements of Pilates and boxing; Rummy O—a tile-based game for two to four players based on matching tiles of the same rank or sequence and same suit; Tai chi—an ancient Chinese discipline of meditative movements, practiced as a system of exercises.

3.3. Face-to-Face Interviews

A total of 22 female RC patrons (mean age 65 years) consented to be interviewed. As shown in Table 4, they were predominantly of Chinese descent (96%), had a partner (96%), achieved primary school education (55%) and resided approximately seven minutes walking distance from their RC. The majority of them attended RC programs on a weekly basis (59%).

Table 4. Profile of interviewed patrons (n = 22).

Age: mean (SD), years	65 (8.8)
Ethnicity, n (%)	
Chinese	21(95.5%)
Malay	1 (4.5%)
Marital status, n (%)	
With partner	21(95.5%)
Without partner	1 (4.5%)
Education level, n (%)	
Primary school	12(54.5%)
Secondary school	8 (36.4%)
University	2 (9.1%)
Distance from residence to centre: mean (SD), walking mins	7.39 (6)
Frequency of attending Recreational Centre, n (%)	
Daily	6 (27.3%)
Weekly	13 (59.1%)
Monthly	3 (13.6%)

SD—standard deviation.

Feedback from participants was grouped into two main categories: (a) RC facilities and activities (both positive and negative aspects); and (b) Suggestions to improve facilities/activities. Supporting quotes from individual participants (P#) are provided below the identified themes when appropriate.

3.4. RC Facilities and Activities

3.4.1. Positive Aspects

Most participants commented that the RCs were conveniently located and met their needs—providing a place to engage with their neighbours and increase their social interaction opportunities.

"It is just a stone's throw from home…. I go to enjoy the facilities …". (P17)

"In the past, I did not really know my neighbours, did not interact much... But with the availability of the coffee corner (at the RC), I use the facility to interact … to make more friends". (P20)

Participants enjoyed the range of activities and described reasons for their continued participation and attendance at the RCs. These reasons included improved mental health, increased social interaction with friends and family, and reinforcement of a healthy lifestyle.

"My qigong classes made me stay physically healthy and active". (P12)

"Stretching classes gave me more time to spend with my husband". (P14)

"I learn about using healthy cooking tips at home and when I am buying groceries". (P17)

RC managers were nominated by the participants as playing a critical role in motivating their involvement in the activities offered.

"RC staff are very nice, approachable and friendly. I made friends with them as they frequently contacted and motivated us to attend upcoming events". (P13)

"RC managers and volunteers do a good job to reach out to the community and benefitted me by increasing my social circle". (P12)

3.4.2. Negative Aspects

Participants indicated that the limited floor area of the RCs made it difficult to accommodate more participants and restricted the facilities provided and the types of activities offered.

"Yoga classes are limited by the small facility where participants cannot do much with limited space". (P4)

"Increasing space may cater to more participants, more activities and bigger events. More funding for communal space can accommodate more people for dance activities". (P7)

Participants nominated several reasons that prohibited them from attending RC activities, such as lack of time due to personal commitments, lack of companionship, physical limitations, language barriers and financial difficulties in paying for the activities.

"I have limited time with family commitments and work occasionally elsewhere". (P17)

"My schedule clashes due to caring for my grandchildren". (P20)

"I prefer to speak my own dialects, i.e., Hokkien or Teochew". (P11)

"Classes are too strenuous for us". (P15)

"Each RC session costs US$2-$5 …. We would prefer 'free' sessions". (P2)

3.5. Suggestions to Improve the Facilities/Activities

Participants proposed age-friendly indoor and outdoor safety fixtures (handrails, non-slip floors) and aesthetically pleasing spaces. Increased government funding to upgrade facilities was also seen as important.

"Facilities should be more user friendly, such as handrail, grab bar with slip resistant toilets". (P4)

"RCs can be beautified with more plants, flowers, herbs and spices". (P14)

"Government can enhance aesthetics of the RC, i.e., waterfall area, mini bonsai gardens and bear the cost of grab bars and slip resistant flooring". (P18)

Additional RC facilities suggested by the participants were diverse. These included a library, karaoke room, dance room, kitchen studio, reading corner and wellness centre.

"Some folks are very good at singing; a karaoke room can display their talent and boost their self-esteem". (P3)

"A dance room could keep us fit. By expanding the kitchen studio, more people can participate in cooking demonstrations". (P7)

Several participants indicated that activities should be social, of interest to them, and free of charge, with incentives seen as attractive motivators for RC participation. Preferred incentives included supermarket vouchers, discounts, reward cards, healthy food product samples, sports towels and Fitbits.

"Low cost educational tours are very enjoyable...we explored new culture, food and sights which foster relationships when travelling as a group". (P2)

"Sponsorship products such as nuts, sesame oil, wholegrain products can encourage healthy eating,

or fitness gears to increase PA, such as a Fitbit". (P4)

"Government can provide RCs with discount cards, reward cards to use at healthier dining outlets". (P15)

Approaches to increase engagement with RC activities included matching of activities to participant's interests and abilities, involving family members, training multi-ethnic older volunteers to run activities, and linking external parties to share expertise.

"I love art and craft in making pretty and beautiful things using my hands". (P11)

"Retro or traditional Chinese music is good for dancing but at a slower pace for inactive people like me". (P15)

"Ensure most activities have focus on family members… cooking competition can involve the children, parents and grandparents together". (P7)

"Reach out to minority groups…. An older leader from different races could lead the fitness class or cooking session". (P19)

"Youth Executive Committee from community centres could be involved in planning of activities to inject more ideas". (P7)

Some participants expressed the need for the additional training of RC managers and more staffing in order to provide activities suited to their interests. Conversely, they also acknowledged that the RC staff do display a genuine interest in promoting healthy ageing initiatives.

"RC staff should be trained to show initiative, and enthusiasm in caring for the older people". (P4)

"RC staff could train participants on gardening as plants can be therapeutic for the mind and help to beautify the RCs". (P14)

"There should be annual seminars for RC staff to share best practices, innovative and successful initiatives in building a more caring community". (P4)

"We should reward RC staff who drive participants to attend wellness activities, such as health promoter of the month or best RC district manager in health advocacy". (P8)

4. Discussion

Despite the promotion of RCs as a recreational venue for older adults and the high demand for such community facilities to support healthy active aging in Singapore [45], there remains limited published information on the facilities and activities offered by RCs and their patrons' perception of these services [40]. With the exception of a small-scaled study of RC resources [45], the present study represents the first comprehensive report on this important topic.

There were several issues raised by the participants regarding the RC facilities. Firstly, the average floor space of the RCs was less than half the size of a tennis court, thus restricting the type of PA activities and facilities that could be offered. Space is limited in Singapore, which presents a challenging problem for RC managers to develop creative ways to manage the limited space available while servicing patrons. One solution may be to stagger activities for more patrons to increase access. The concern about limited space in RC indicates the necessity for government support to upgrade and expand RCs, to ensure the continuation of RC activities to meet the social and health needs of Singapore's ageing population. Eighty percent of the RC managers reported receiving government funding in the last 12 months, but the amount of such funding might not be adequate to upgrade facilities.

The audit revealed more opportunities to engage in PA within the RC environment than nutrition and social activities. The small-scale piloted study, undertaken in seven residential zones within one Singapore district (West region), similarly reported that PA was the main activity offered within RCs and their tendency to prioritise PA [45].

The importance of active lifestyle-enabling features for healthy ageing in cities is well recognised [56]. Examples of such features identified in the present study were hazard-free walkways with adequate lighting, outdoor facilities (park, fitness station, sports court, and bicycle rack) and nearby amenities (eateries, medical clinics, and efficient transport system). These environmental features will enable more PA opportunities, as evidenced in a cross-sectional study of 14 cities which showed increased PA in densely populated neighbourhoods with walkable interconnected streets, close amenities and parks [7]. In addition to these PA enhancing features, the patrons also provided suggestions to support their PA levels, such as *"attractive wall murals with 'get active' messages"*, *"walking initiatives at nearby nature trails"* and the *"enhancement of aesthetics of the RCs through installation of a waterfall area or mini bonsai gardens"*. These suggestions should be considered by the RC management.

The focus on PA is reasonable and acceptable, especially when considering that 61% of Singaporean adults are not meeting the PA guidelines of more than 150 minutes of moderate activity each week for health benefits [20], along with the positive health benefits associated with being physically active [57]. Activities such as walking are inexpensive, requiring no special equipment or skills and, when conducted in groups, can enhance social connectedness [58]. However, the promotion of healthy eating is equally important, since many Singaporean adults aged over 50 years have exceeded the recommended dietary allowance for energy, total fat, saturated fat and carbohydrates [19]. Our study found the RCs provided limited nutrition-related facilities and activities both inside (kitchen (36%) and kitchen appliances (46%)) and outside (vegetable/fruit/spice garden (36%), coffee benches (58%) and vending machines (33%) stocked with healthy snacks). To support healthy dietary behaviours, the social and physical features of the RC could be altered by environmental cues [10,11]. For example, increasing the availability of healthier products in the vending machines would stimulate healthy snacking. RC managers could improve the aesthetic of the coffee benches and the kitchen to increase social interaction, provide healthy culinary courses for patrons, and develop community gardens. Community gardens, for instance, have many benefits that include developing social networks and friendships, increasing a sense of happiness and reducing stress through social interaction, improving access to fresh and nutritious vegetables [59], as well as replacing fast food consumption by fruit and vegetables [60]. A global meta-analysis confirmed the beneficial effects of gardening on mental wellness (depression, anxiety and life satisfaction), health outcomes (body mass index and quality of life) and general health [61]. The installation of community gardens is possible since 72% of the RCs were observed to occupy more than one grassy area (> 6m × 6m) outside their premises.

Based on the principles of the socio-ecological model and SCT concepts, the interaction of the interpersonal, physical environment and socio-cultural factors can either inhibit or facilitate engagement in health behaviours [46,62]. Several factors facilitated the engagement of patrons to utilise the RC, as reflected by their opinion: *"It is just a stone's throw from home"*, *"enjoy the facilities"*, *"use the facility to interact"*, *"make more friends"*, and *"stretching classes gave me more time to spend with my husband"*. On the other hand, factors that hindered their RC involvement should be addressed: *"prefer to speak my own Chinese dialect"* and *"classes are too strenuous for us"*. They also suggested a range of strategies to optimise engagement with RCs, such as increasing staff and volunteer training, recognition of staff commitment, involving families, provision of healthy incentives and considering patron's interests and abilities. Participants suggested alternative activities, such as *"making pretty and beautiful things with my hands"*, *"dance of slower pace to cater for the inactive participant"*, and *"gardening as plants are therapeutic and help to beautify the RCs"*. Age-friendly facilities such as the installation of handrails, non-slip floors, kitchen studio, dance and karaoke rooms were also proposed, which are worthy of consideration for future program planning. Moreover, the patrons nominated RC managers as playing a vital role in promoting health. A diverse range of adaptable facilities and customised activities should be provided at flexible times to keep them physically fit and socially active. Early involvement, consultation and engagement between managers and patrons should be encouraged to modify or refine facilities and activities, in order to motivate PA and dietary behaviour change. They further acknowledged the need for RC managers to be educated through

annual seminars and be rewarded for their contribution. These findings can be used to better inform government to suit the RC patrons' changing physical abilities, demands and interests.

Future research should examine the impact of the RC activities and facilities on offer and their cost effectiveness in terms of reducing NCDs. Researchers could collaborate and innovate health promoting RC environments that are conducive to healthy aging. Comparisons between and within various RCs could be conducted to inform ways to manage resources more efficiently and promote best practice strategies and policies that reinforce and accelerate health-enhancing behaviours.

5. Conclusions

The capacity for the physical and social environment to positively influence PA and dietary habits has been well documented. This study revealed that RC facilities and activities primarily placed a greater emphasis on PA and less on healthy eating practices. The positive and negative aspects of RCs nominated by patrons should be reviewed by RC managers, along with their suggestions to improve the activities and facilities when promoting health behaviours. In particular, the provision of aesthetically pleasing RC environments, monetary incentives and healthy refreshments were highly recommended by RC patrons to motivate them to stay active and eat well. RCs serve as desirable community hubs to enhance healthy behaviours through appropriate activities and social connectedness. Collaboration between managers and patrons is paramount in making the RC facilities and activities relevant and supportive of active participation in healthy lifestyles. RC patrons have reported a strong interest in programs that focus on building social ties with their families and peers, while regarding RC managers as positive role models in encouraging them to sustain behavioural changes. The development of policy to regularly assess and modify the RC environment could positively instigate PA and healthy eating practices to address the high rates of chronic diseases in Singapore.

6. Limitations

The present study represents the most comprehensive report on RCs in Singapore. The interviews were undertaken with female patrons because they constituted the predominant users of RCs (82%). It would be of interest to find ways on how to attract more men to RCs. The qualitative analyses were based on 22 interviews. Future surveys should be undertaken on a large number of participants across RCs to confirm our findings. In addition, once recorded, the interviews were translated from Mandarin and Chinese dialects into English, which might induce minor impacts on our interpretations. Since the study focused on specific types of services in a specific socio-geographical context, the generalisability of the findings is somewhat limited. Finally, future research should consider using cluster randomisation (i.e., same percentage of RCs in each area) to ensure equal representation of RCs.

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Abbreviations

APARS	Audit of Physical Activity Resources for Seniors
HPB	Health Promotion Board
QALY	Quality-adjusted life-years
NCD	Non-communicable diseases
PA	Physical activity
PI	Principal Investigator
RC	Recreational Centre
SCT	Social Cognitive Theory
SD	Standard Deviation

Appendix A. Interview Schedule

- What do you like about the facility/facilities?
- What do you like about the activity /activities?
- What activity/activities do you participate in?
- What Recreational Centre facilities would you will like to see more/less of? Why?
- What activities would you like to participate in more/less of? Why?
- Has the Recreational Centre facilities and activities benefited you?
- What do you think motivates you to use the Recreational Centre facilities?
- What do you think motivates you to participate in the activities?
- What do you think would make you more likely to use the Recreational facilities and the activities?
- What do you think Recreational Centre managers and volunteers could do to improve the current facilities and activities in the community?
- What suggestions do you have on how government or other agencies could help to improve the Recreational Centres to support the health status of residents?

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4.2 Process evaluation

Publication 3:

Process Evaluation of the Singapore Physical Activity and Nutrition Study

It addresses objective 3:

- Evaluate the appropriateness and acceptability of the intervention strategies and resources for the target group.

Citation:

Wong, E. Y.-S., Lee, A. H., James, A. P., & Jancey, J. (2020). Process evaluation of the 'Singapore Physical Activity and Nutrition Study'. *Evaluation and Program Planning*, 83, 101847. https://doi.org/10.1016/j.evalprogplan.2020.101847

4.2.1 Summary of process evaluation results

Of the 351 eligible intervention participants, 56 withdrew from the intervention. Reasons for withdrawals included personal commitments, relocating overseas, fear of needles, loss to follow-up, health issues, moved out of the area, forgetfulness and death of a spouse. Most participants (78%) attended half of the PA classes and nutrition workshops, while 66% attended at least three-quarters of all the sessions over 6 months. Phone counselling sessions (72%) were the most preferred intervention strategy, followed by nutrition workshops (65%) and PA classes (60%). The main reasons for non-participation included busy schedules, time clashes with other commitments, overseas holiday and health issues. Participants reported high levels of satisfaction with the overall program (99.5%), program activities (96.7%) and rated program ambassadors highly.

A combination of acceptable strategies such as customised programs (PA workout, nutrition workshop and phone dietary counselling session), practical resources (calendar and health booklets) and motivational interviewing techniques used by the program ambassadors supported program adherence. Health benefits, enjoyment, social bonding and community networking with family and friends were nominated as key reasons for motivating their health pursuits towards program completion. Non-completers commented that they preferred a slower PA pace during fitness classes, bilingual sessions and shorter program duration. Nevertheless, they still complimented the sessions as relevant and beneficial in improving their PA and eating behaviours. Other suggested improvements included more PA guidance in postural correction, videos of PA classes to take home and personalised assessment of accelerometry data to motivate them to wear the device. Periodic and timely program modifications were made by RCs' managers and program ambassadors, with inputs from the participants, to increase the acceptability and appropriateness of intervention strategies and resources.

More details are provided in publication 3 below that addresses objective 3.

Publication 3

Process evaluation of the 'Singapore Physical Activity and Nutrition Study'

ABSTRACT

Introduction: The Singapore Physical Activity and Nutrition Study (SPANS) aimed to improve the physical activity (PA) and nutrition behaviours of Singaporean women aged 50 years and over. The SPANS program consisted of PA classes, nutrition workshops, telephone dietary counselling, health booklets, a health calendar and program ambassadors. This study aimed to assess and understand the implementation of the program strategies, gain insight into process evaluation components, to inform future programs.

Methods: The evaluation was guided by a process evaluation framework and collected data via questionnaires (n=209), program ambassador documentation and exit interviews with program completers (n=13) and non-completers (n=12).

Results: In total 295 participants completed the program (response rate of 84%). Participants reported high levels of satisfaction for the overall program (99.5%) and program activities (96.7%), and also rated program ambassadors highly. Participation rates were highest for telephone dietary counselling sessions. The main reason for not attending program activities was having a 'busy schedule' (n=158). Participants cited a need for improved recreational centre facilities and increased flexibility around program delivery.

Conclusions: The process evaluation showed that the program strategies were implemented as planned and were deemed suitable for supporting behaviour change among Singaporean women aged 50 years and over. The program reached and involved the majority of participants throughout the six-months. The combination of practical educational resources and supportive program ambassadors were key strategies that facilitated positive PA and dietary behaviours, however, there needs to be some flexibility in the delivery of programs. The findings of this research may inform other programs in the region.

Keywords: Behaviour change; community-based program; physical activity; non-communicable diseases; nutrition; program evaluation.

INTRODUCTION

The rising level of non-communicable diseases (NCDs) is a worldwide phenomenon. The World Health Organization (WHO) called upon its 194 global members to intensify their physical activity (PA) and nutrition programs to reduce the rates of NCDs (World Health Organization, 2017). The effectiveness of community-based PA and dietary programs aimed at combating NCDs is well-supported by evidence-based research (Blackford et al., 2017; Ding et al., 2016; Hyseni et al., 2016; Jancey et al., 2019).

In Singapore, NCDs account for 60% of deaths (Dans et al., 2011) with a very high incidence of cancer, heart disease and type 2 diabetes (Epidemiology & Disease Control Division, 2019). Singaporean women aged 50 years and over are particularly at risk due to their unhealthy diet and insufficient levels of PA. Most women in this 'at risk' group exceed the recommended intake for energy (58%) and fat (57%), do not meet the recommended dietary fibre requirements (62%) (Health Promotion Board, 2013) and report high levels of leisure-time physical inactivity (72%) (Ministry of Health, 2011).

In response to this, the Singapore Physical Activity and Nutrition Study (SPANS) was implemented to improve PA and dietary behaviours of Singaporean women aged 50 and over attending their neighbourhood recreational centres (RCs). RCs are public facilities that support social leisure activities and are located below high rise public housing. They are conveniently-located hubs for implementing lifestyle programs and facilitating lifestyle practices for older Singaporean women (Wong et al., 2019).

The SPANS program comprised of 1) educational resources that included PA and nutrition booklets, a health calendar based on Singapore's PA and nutrition guidelines (Health Promotion Board 2015a, 2015b), 2) 12 PA classes (week 2 - 24), three nutrition education workshops (week 1, 12 and 24) and three telephone dietary counselling sessions (at week 4, 12 and 20). These strategies supported lifestyle behaviour change

as evidenced by previous PA and nutrition studies (Blackford et al., 2017; Burke, Jancey, et al., 2013; Burke, Lee, et al., 2013; Chee et al., 2017; Jancey et al., 2017; Jung, Lee, Lee, Kwon, & Song, 2012; Tran, Jancey, et al., 2017). Trained program ambassadors (i.e., final-year nutrition, sports and wellness students (n=13), qualified nutritionists (n=2) and a certified fitness instructor (n=1)) organised and conducted the program strategies. They were responsible for the baseline and post-program data collection, as well as the fitting of accelerometers. The accelerometers measured PA levels objectively. They were worn by the participants on their right hip for seven consecutive days (pre and post-program) and removed when showering, swimming and sleeping (Aguilar-Farías et al., 2014). A detailed overview of the accelerometer can be found in the published protocol paper (Wong et al., 2018). The control group participants received a falls prevention booklet and were blinded to the nature of the program. The outcome evaluation results currently under review elsewhere (Wong, Lee, James, & Jancey, 2020), have shown statistically significant improvements in moderate and vigorous-intensity PA and dietary behaviours in the intervention group compared to the control group

This study presents the first report on a comprehensive process evaluation of the SPANS in Singaporean RCs. Previous research has argued that it is necessary to carry out a mixed-methods process evaluation to identify program characteristics and opportunities for improvements (Haynes et al., 2014; Liu et al., 2016; Moore et al., 2014). Process evaluation is widely used to determine if a program has been implemented as intended, investigates reasons for attrition, identifies acceptability of a program and provides insights into program outcomes (Lavinghouze & Snyder, 2013; Saunders, Evans, & Joshi, 2005; Shimazaki & Takenaka, 2015; Sranacharoenpong, Hanning, Sirichakwal, & Chittchang, 2009; Tran, Jancey, et al., 2017).

Involving participants and program ambassadors during process evaluation helps to ensure timely feedback, which improves program quality (Schijndel - Speet, Evenhuis, Wijck, & Echteld, 2014). Despite the many advantages of conducting process evaluation, the majority of lifestyle programs often neglect this form of evaluation, instead choosing to focus on impact and outcome evaluation (Olstad et al., 2016; Saunders, Wilcox, Baruth, & Dowda, 2014; Viester et al., 2014). Bauman and

Nutbeam (2013) advised that process evaluation enables the researcher to determine if a program was implemented as intended and identifies conditions that are needed to achieve successful program outcomes, which can then inform future programs. They concluded that if process evaluation is not conducted, researchers may not understand why a program was successful or unsuccessful. Therefore, this study aimed to assess and understand the implementation of the program strategies, gain insight into process evaluation components to inform future programs.

METHODS

Setting and theory

This study describes the process evaluation of the larger SPANS program, a six-month randomised controlled trial (RCT) targeting community-dwelling Singaporean women aged 50 and over, who attended RCs across three Singaporean districts. The trial was registered with the Australian and New Zealand Clinical Trials Registry (trial no: ACTRN12617001022358) and details of recruitment and screening have been reported elsewhere (Wong et al., 2018).

Social Cognitive Theory underpinned the SPANS and was supported by several psychosocial constructs (Glanz et al., 2008). These constructs were a) self-efficacy– participants were educated on the benefits of healthy eating and regular PA, b) skill development– participants were encouraged to adopt and practice health-enhancing habits and c) positive reinforcement and observational learning through regular feedback and shared health experiences with other participants (Bandura, 2004; White, Wójcicki, & McAuley, 2012). Moreover, motivational interviewing strategies were implemented to positively influence PA and dietary behaviours (Cummings et al., 2009; Rollnick, 2010).

Process evaluation design

The SPANS program adapted the process evaluation framework developed by Saunders et al. (2005) for assessing program implementation. This framework has been effectively used in comparable six-month PA and nutrition programs with older adults to pinpoint preferred strategies for facilitating behaviour change (Blackford et al., 2017; Tran, Jancey, et al., 2017). Process evaluation components based on Saunders et al.'s (2005) framework assessed a) ways to attract participants and

maintain their engagement (recruitment), b) the number of active program participants (reach), c) factors that affect implementation and outcomes (context), d) the extent to which program implementation occurred as planned (fidelity), e) number of intended program strategies conducted (dose delivered-completeness), f) the extent to which participants used resources as recommended (dose received-exposure) and g) the satisfaction of participants with program and staff (dose received-satisfaction). Table 1 is based on the Saunders et al. (2005) framework and summarises the process evaluation components and the corresponding data collection instruments.

Table 1: Process evaluation components and data collection instruments

Process evaluation components	**Data collection instruments**		
	Self-completed questionnaires	Semi-structured exit interviews	Program ambassadors documentation
Recruitment –attract participants and maintain engagement			X
Reach – number of active program participants	X	X	X
Context – factors that affect program implementation and outcomes	X	X	X
Fidelity –the extent to which program implementation occurred as planned			X
Dose delivered (completeness) – number of intended program strategies conducted	X	X	X
Dose received (exposure) – the extent to which participants used resources as recommended		X	X
Dose received (satisfaction)- the satisfaction of participants with program and staff	X	X	X

Data collection procedure

The questionnaire and exit-interview were adapted from previous instruments used in process evaluation studies that have been effective in measuring behaviour change (Blackford et al., 2017; Tran, Jancey, et al., 2017). Two trained program ambassadors pilot-tested the bilingual (English and Chinese) questionnaire (n=10) and exit interviews (n=5) with other peer-aged female RC patrons to improve clarity and comprehension before administration to the target group. The measuring instruments were modified according to the respondents' suggestions (e.g., reduce the number of questions and simplify the structure of the questions). Conversely, the RC patrons commented that no changes were required for the exit interviews.

An information sheet with the researchers' contact details was provided to the participants. Program ambassadors informed participants of the study's purpose, objectives and procedure. A signed, informed consent form outlining the study's protocols and confidentiality was obtained from the participants prior to data collection. All program participants were invited to complete the questionnaire, and those participating in the interviews were purposefully selected. Both qualitative and quantitative data were collected.

Data collection instruments

Self-completed questionnaire

At the final PA session (session 12, week 24), participants completed a questionnaire that assessed the program and program ambassadors (i.e., clarity or presentations, delivery skills, approachability and knowledge) (see Supplementary file 1) and satisfaction with the program (i.e., activities, pace, sustainability and program overall). A five-point Likert-scale (1-poor, 2-fair, 3-satisfactory, 4-good and 5-excellent) was adopted to establish satisfaction with the program (i.e., pace and sustainability of interest) and program ambassadors (i.e., clarity of presentation, delivery skills, knowledge and approachability). Open-ended questions were included for participants to provide commentary on what they liked and did not like, as well as recommendations for program improvements.

Semi-structured exit interview

On completion of the program, exit interviews were conducted with program completers (n = 13) and non-completers (n = 12). The interview consisted of a 10-point Likert scale to assess the program ambassadors (1=poor to 10=excellent) and open-ended questions to determine a) program engagement, b) perception of program strategies, c) support and guidance provided by the program ambassadors, d) changes in attitudes and behaviours towards PA and dietary habits and e) suggestions for program improvements (see Supplementary file 2). Respondents opted for non-audio-recorded interviews. Therefore, the trained interviewers recorded the interviews by hand. Each interview lasted approximately 45–60 minutes and was conducted in English or Chinese.

Program ambassadors' documentation

At the end of each PA class and nutrition workshop throughout the six-month program, a 15-minute group discussion was undertaken by program ambassadors. This process collected feedback relating to the program and its strategies. It identified any issues that might impact attendance and acceptability of program strategies, together with recommendations for improvements. Recruitment and data collection challenges were documented throughout the program. Program ambassadors recorded participants' feedback after each session in their logbooks and reported this information to the principal investigator (PI), who monitored the feedback and responded to the need for any program modifications. Program ambassadors recorded participants' attendance at PA classes (n=12), nutrition workshops (n=3) and dietary counselling sessions (n=3). Follow-up telephone calls were made to participants to identify reasons for their absence at any program sessions.

Analysis of data

Thematic analysis

Data collected via the self-completed questionnaires, exit interviews and program ambassadors' documentation were translated from Mandarin or Chinese dialects into English. Thematic analysis of the transcribed qualitative data was conducted by two trained researchers. As guided by Braun and Clarke (2008), they familiarised themselves with the data, reviewed, and coded the data and established themes. Identified themes were supported by direct quotes from the participants. Qualitative

data from the questionnaire, exit interviews and program ambassadors' documentation were organised, sorted and managed using the NVivo 11 software (QSR International, 2017). The two trained researchers reviewed the data and reached a consensus.

Statistical analysis

Descriptive statistics were used to summarise the participants' demographic profile. For the self-completed questionnaire, responses to the five-point Likert scales (1= poor to 5 = excellent) for the program and program ambassadors were recoded into dichotomous variables (unsatisfactory (1-2) and satisfactory (3-5)). Percentages of dichotomous variables and attendance at sessions and workshops were calculated using the Statistical Package for Social Science version 25 (IBM Corporation, 2017). Mean scores for the Likert scale rating (scale 1-10) for program ambassadors (i.e., nutritionists and the fitness trainer) were also calculated for the exit interviews.

RESULTS

Participant demographics

In total, 295 Singaporean female residents aged 50 years and over completed the program, the majority of whom (mean age 64, SD 7.9 years) were of Chinese descent (96%), married (76%) with high school education (54%). About one-third (32%) lived in four-room government flats (see Table 2).

Table 2: Characteristics of female participants (n=295)

	n	%
Age mean (SD) years	64 (7.9)	
Chinese	282	95.7%
Malay	7	2.4%
Indian	6	1.9%
Education level		
Primary or no education	71	23.9%
High/secondary school	160	54.1%
College	32	11%
University/tertiary education	32	11%
Marital Status		
With partner	223	75.6%

Without partner (widowed, single or divorced)	72	24.4%
Housing Type		
Government		
Two-room flat	14	4.8%
Three-room flat	58	19.6%
Four-room flat	95	32.1%
Five-room flat	54	18.2%
Private Property	60	20.4%
Others (1 room, executive flats, maisonette)	14	4.9%

SD- standard deviation

SPANS Program

Program withdrawal

Of the 351 participants who initially commenced the six-month SPANS, 295 completed the program (retention rate of 84%). Reasons nominated by participants (n=56) for withdrawing from the 6-month program included being busy with family, work and volunteer commitments (n = 38), relocating overseas (n = 4), fear of blood tests (n = 4), uncontactable (n = 4), health issues (e.g., cataract, immobility and dizziness) (n = 3), relocation (n = 1), forgetfulness (n = 1) and death of spouse (n = 1). Non-completers reported that they participated for a period ranging from two to five months.

Program participation

The majority of participants (78%) attended at least half of the PA classes and nutrition workshops, while 66% attended at least three-quarters of the sessions. The highest participation rates were for the telephone dietary counselling (72%), followed by nutrition workshops (65%) and PA classes (60%) (see Table 3).

Table 3: Participation in program activities

Telephone dietary counselling sessions (n=3)	**n**	**%**
Session 1	212	89
Session 2	181	76
Session 3	182	76
Attendance level ≥75%	172	72

Nutrition workshops (n=3)		
Workshop 1	189	79
Workshop 2	208	87
Workshop 3	172	72
Attendance level ≥75%	155	65
Physical activity classes (n=12)		
Class 1	233	97
Class 2	171	72
Class 3	169	71
Class 4	183	77
Class 5	172	72
Class 6	188	79
Class 7	172	72
Class 8	172	72
Class 9	163	68
Class 10	168	70
Class 11	181	76
Class 12	163	68
Attendance level ≥75%	143	60
Attendance across all activities		
Attendance level ≥ 75%	157	66
Attendance level ≥ 50%	186	78

Participants (n=295) reported several reasons that prevented them from achieving full participation at all sessions listed in Table 3. These included busy schedules (n=158), time clashed with family activities, caretaking, working and volunteering (n=32), overseas holidays (n=17), health issues (n=13), forgetfulness (n=3), preference for PA to be conducted indoors (n=3), fear of falling during wet weather (n=3) and the belief that PA classes were tiring (n=2).

The identified program themes were a) program satisfaction, b) program outcomes, c) program improvements, d) program resources and e) program ambassadors (reported below).

Program satisfaction

Of the 295 participants, 209 (71%) completed the questionnaire. A large majority of participants reported high satisfaction rates for the overall program (99.5%), program

activities (96.7%), program pace (96.7%) and sustainability of program interest (96.2%). The participants enjoyed the program, which increased their desire to improve their health. For example, *"I enjoyed the nutrition and fitness sessions, including the dietary counselling sessions that motivated me to enhance my health"* (Questionnaire 86). Almost all participants (99%) reported that they would recommend the program to friends, family or other people: "*I will recommend to people who have the time to take part in it as it is a good program to learn about healthy living"* (Questionnaire 156). Even non-completers were satisfied and complimented the relevance of learning more about a healthy lifestyle. "*It was a good program to learn about healthy living. I would recommend to people who have the time to take part in it as it is a good program to learn about healthy living" (*Interview 10*).* The program also provided opportunities for social support and time to bond with friends and family: "*…allow bonding with my sister and cousin that motivate me to change my diet"* (Questionnaire 171) and "*The fitness program pushed me to exercise and was also a good platform from which to get to know people"* (Questionnaire 201).

Program outcomes

A sub-sample of participants was interviewed (n=13) and reported that the SPANS had motivated them to increase their PA levels. More than half (n=8) participated in PA sessions such as yoga, aerobics and dance classes (Flamenco, Performance, Bollywood, Zumba and Bokwa) offered elsewhere. Nine completers made dietary change by eating less fried foods, fatty meat, sugary foods, meat, salt and oil and eating more whole-grains, dairy products, vegetables and fruit; while dining out less often. Some completers became motivated to search online for nutritional information on functional foods, calorie intake and food labels, with comments such as "*I seek knowledge online on reading labels, calories and functional foods"* (Interview 10) and *"when buying products in the supermarket, I look out for the healthier choice symbol"* (Interview 11).

Program improvements

Participants recommended promoting the program via 'word of mouth' to friends and family members and they also emphasised sharing program benefits: *"… seniors can explain how healthy living has positively impacted their life"* (Questionnaire 78). In addition, they suggested more frequent nutrition workshops (bi-weekly), bilingual language instructors and provision of refreshments and rewards (e.g., supermarket

vouchers). Suggested future education topics included mental wellness and women's health issues.

Recommendations for PA classes included multiple timeslots and longer class durations (> 1 hour): *"There could be more fitness classes per week for those who are busy on other days"* (Interview 9). There were requests for more yoga and dance classes with guidance in posture correction, larger RC facilities for PA classes, a slower pace for inactive adults and videos of PA classes to take home. The need to eliminate participants' negative perceptions about wearing the accelerometer device (i.e., inconvenient, uncomfortable and visually unappealing) was highlighted. Participants suggested that program ambassadors should educate about the importance of the accelerometers in measuring PA levels and provide them with personalised report of their accelerometry data to improve their acceptance of wearing the device. The participants also perceived that dietary counselling was best conducted face-to-face rather than by telephone, as a means of increasing the rapport between the participant and the program ambassador.

Program resources

Overall, the participants commented that the program resources were valuable and that they used the educational resources as recommended: "*Good stretching exercises and the visual resources provided in the nutrition sessions facilitate understanding and were useful to learn about healthy living"* (Interview 9). The information was found to be age-appropriate: *"I learned more about exercise and nutrition messages in this holistic program suited to my age group"* (Interview 3). Participants found the resources to be easy-to-read, appealing and provided simple messages. For instance, "*The instructions in the health and recipe booklets are simple to follow* (Interview 13). *They are colourful, attractive and easy to read"* (Interview 11*) and "The recipes in the booklet were easy to cook yet tasted good… practical and helpful"* (Interview 5).

Program ambassadors

Program ambassadors (i.e., nutritionists and the fitness instructor) were reported as excellent educators in regards to their clarity during the presentation (99%), delivery skills (99%), approachability (98.6%) and knowledge (98.6%). Participants stated that the ambassadors were highly suited to their roles with supporting quotes such as *"their*

energy level and passion in teaching are commendable" (Questionnaire 112). Program ambassadors scored highly on the 10 points Likert scale (mean=8.4) in their teaching of PA and dietary information. They provided clear, simple and useful health information with supportive quotes: "*It was helpful and the presentation was short and sweet. Yet, I gained good knowledge and I am more aware of my health"* (Interview 13). The ambassadors were also friendly, approachable and knowledgeable with supporting quotes such as: "*Moves demonstrated by the fitness instructors are very good, professional and look very easy" (*Questionnaire 89*). "I felt that the trainers were encouraging… gained lots of knowledge that I found very beneficial for my blood circulation" (*Questionnaire 210*) and "the nutritionists were approachable and knowledgeable"* (Interview 9).

DISCUSSION

The process evaluation of the SPANS was conducted to assess and understand the implementation of the program strategies, gain insight into process evaluation components to inform future programs. The results demonstrated that the program was delivered as intended with appropriate program strategies and resources, supporting and motivating participants to change their PA and dietary behaviours.

The high retention rate (84%) for the SPANS indicated good participant reach, adherence and acceptance of the program. Of those who withdrew from the program, the main reason was 'busy with family, work and volunteer commitments', which was consistent with comparable process evaluation studies of community-based PA and nutrition RCTs (Blackford et al., 2017; Burke, Jancey, et al., 2013; Burke, Lee, et al., 2013; Jancey et al., 2018; Tran, Jancey, et al., 2017). This is a challenging issue to address because individuals do have competing life priorities. There may be a need for more flexible approaches, such as encouraging home-based activities and resources. Home-based programs have been successfully used with older adults in other countries (Blackford et al., 2017; Burke, Jancey, et al., 2013; Burke, Lee, et al., 2013) but they have not been trialled in Singapore and this is something to investigate in the future.

An average attendance of 66% was achieved across the program activities (i.e., PA classes, nutrition workshops and dietary counselling sessions), showing that these sessions were reasonably suitable out-reach strategies for this target group. Nearly all

participants were satisfied with the program activities, enjoyed the activities and were motivated to improve their health. Health benefits and social bonding with family and friends were key reasons that attracted the participants to maintain program engagement. Telephone dietary counselling achieved the highest participation rate, which may make it a priority strategy for future lifestyle programs. The motivational interviewing techniques used in the telephone discussions were well received and supportive of increasing positive behaviour change. Advantages to telephone counselling include convenience and the ability to provide prompt personalised feedback and reinforcement of positive behaviour change (Kim et al., 2013). This strategy also helps to counteract the main nominated barrier to attendance at the sessions and workshops, which was a busy schedule. Beyond this, some participants suggested face-to-face delivery for dietary counselling sessions as a means of strengthening rapport between participants and program ambassadors. Prior research into Asian lifestyle programs has found that face-to-face personalised nutrition education increased program adherence and enhanced dietary changes (Chaiyasoot et al., 2018; Charunee et al., 2018).

The role of program ambassadors and the printed resources were also integral to the program. The program ambassadors played a crucial role in educating and motivating the participants to make positive behaviour change, and the participants found the printed resources to be attractive, age-appropriate and easy to understand. The role of program ambassadors and the use of printed resources have been shown to be effective strategies in previous PA and nutrition studies with older adults (Blackford et al., 2017; Burke, Jancey, et al., 2013; Jancey et al., 2018; Tran, Jancey, et al., 2017) and they appear to be suitable strategies for this target group of older Singaporean women.

The conveniently located RCs were an attractive venue, acting as a community hub to promote and increase leisure-time PA and healthy eating. As venues, RCs can increase social connectedness with other peer-aged participants, by engaging them in health programs within their communities (Wong et al., 2019). However, the participants did identify the need to increase the size of RCs, as space constraints in the centres made implementing indoor health programs challenging. RCs are unique venues synonymous to Singapore and they are popular and accessible (Heath et al., 2012;

Wong et al., 2019). Therefore, more opportunities for increased investment in RCs to support healthy aging are warranted.

One component of the program that was not well received was the use of accelerometers; many participant's refused to wear the device. This challenge has been documented in previous studies, with participants refusing to wear a device due to discomfort, inconvenience, unappealing appearance and restriction in clothing choice (Huberty, Ehlers, Jonathan Kurkarbara, & Buman, 2015; O'Brien et al., 2017). As suggested by Tedesco, Barton and O'Flynn (2017), functional (i.e., unobtrusive, comfortable and effortless) accelerometers for research need to be designed to increase participants' acceptance and enthusiasm for wearing them. Those participants who did wear an accelerometer (n=65) suggested leveraging off the accelerometer data through the provision of personalised reports on PA levels. This approach would provide feedback to the participants and potentially make the wearing of accelerometers more appealing.

Overall, the SPANS program was well-received by the participants, and the program ambassadors' post-session feedback assisted in modifying the program to suit the participants' preferences and needs. For example, PA classes, nutrition workshops and telephone counselling were offered at alternative times to cater to busy participants. It is recognised that regular post-session reviews contribute to modifications to support the relevance and acceptability of the program to the target group (Lobo, Petrich, & Burns, 2014).

Strength and limitations

The main strength of this study was the fact that data was collected from multiple sources using both qualitative and quantitative methods, thus providing a comprehensive view of the implementation and acceptance of program strategies. However, social desirability and researcher bias might have affected the findings. Moreover, the participants might have been more motivated than those who chose not to participate in the program. Future research could explore whether these process evaluation components were sufficiently objective and adequately documented.

CONCLUSION

This study represents the first comprehensive process evaluation conducted on a program targeting older women in Singapore's recreational centres. The process evaluation demonstrated that the SPANS program was implemented as intended and engaged the majority of participants throughout the six-month program. The participants were satisfied with the program, resources and program ambassadors, indicating the appropriateness of these strategies for this target group, particularly with regards to the use of telephone for dietary counselling. The combination of practical educational resources and supportive program ambassadors were key strategies that facilitated positive PA and dietary behaviours. Participants' suggestions for program modification will be beneficial to the implementation of future programs, potentially increasing the relevance and suitability for older community-dwelling Singaporean women at risk of NCDs.

LESSONS LEARNED

Process evaluation is an essential part of program implementation. Such an evaluation should be undertaken to determine if the program was implemented as intended and to establish what worked and what did not work to understand why the program was successful or unsuccessful. Record keeping and participant involvement in process evaluation should occur during all stages of the process evaluation, and a variety of data collection tools should be used. Those implementing programs should keep communication channels with participants open and respond to participant feedback in a timely manner to improve program acceptability and maintain engagement. Data gathered at the end of each workshop and class over the course of the program supported timely feedback and program modification.

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Conflicting interests

The authors declare that they have no conflicting interests.

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4.3 Changes in outcome measurements

Publication 4:

Effectiveness of a Singaporean community-based physical activity and nutrition intervention: A cluster randomised controlled trial

This addresses objectives 4 and 5:

- Assess changes in PA, sedentary and dietary behaviours of the intervention group participants relative to the control group participants from pre- to post-test.
- Assess the changes in blood pressure (BP), anthropometric measurements, fasting blood glucose (BG), lipid profiles and health-related quality of life (HR-QOL) indicators of the intervention group participants relative to the control group participants from pre- to post-test.

Citation:

Wong, E.Y.-S., James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: A cluster randomised controlled trial. *Asia Pacific Journal of Public Health*. https://doi.org/10.1177/1010539520977311

4.3.1 Summary of outcome measurements results

A final analysed sample consisting of 295/351 intervention (84%) and 285/331 control (86%) group participants completed the post-test. After controlling for confounders (age, ethnicity, education level, marital status, housing type, health condition, medication usage and clustering effect), the generalised estimating equations analyses confirmed statistically significant increases in moderate-intensity PA (65.2 metabolic equivalent of task (MET)-minutes per week, $p < 0.001$), vigorous-intensity PA ($p < 0.001$), total PA (1123.5 MET-minutes per week, $p < 0.001$) but not for walking and cycling PA ($p = 0.454$) and sitting time ($p = 0.190$) by the intervention group relative to the control group over the 6 months (see **Appendix U** and **W**). Accelerometry data for a sub-sample of the intervention participants (n = 65) supported the findings of the self-reported PA and sedentary behaviour measures, with statistically significant increases in moderate ($p < 0.001$) and total PA ($p = 0.003$) but not for vigorous PA ($p = 0.106$) and sitting time ($p = 0.910$) between the two time points (see **Appendix V**). Statistically significant improvements were also observed in self-reported frequency of intake of fruit ($p = 0.001$) and vegetables ($p = 0.049$), wholegrains ($p = 0.041$) and a reduction in intake of salt and salty sauces ($p = 0.042$) and sugary beverages ($p = 0.019$) but not for fatty foods ($p = 0.973$) in the intervention group relative to the control group from pre- to post-test (see **Appendix W**). For anthropometric and BP measurements and fasting BG and lipid profiles, statistically significant reductions in the intervention group compared to the control group from pre- to post-test were found only for systolic BP ($p = 0.020$), diastolic BP ($p = 0.001$) and body fat percentage ($p < 0.001$), after accounting for confounders. For the HR-QOL indicators, only a statistically significant improvement was reported in the 'no bodily pain' ($p = 0.039$) indicator in the intervention group compared to the control group from baseline to post-intervention, after controlling for confounders (see **Appendix X**).

More details are provided in publication 4 below that addresses objectives 4-5.

Effectiveness of a Singaporean community-based physical activity and nutrition intervention: A cluster randomised controlled trial

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Abstract

This study examined the effectiveness of a 6-month intervention to improve the health behaviours and outcomes among women aged 50 and over. A sample of 580 (intervention n = 295; control n = 285) women was recruited from 26 recreational centres. Only the intervention group participated in the Singapore physical activity (PA) and nutrition study (SPANS), received health resources (calendar, recipe and booklets) and motivational support from program ambassadors. The intervention group showed significant improvements in moderate-intensity PA, vigorous-intensity PA and total PA ($p<0.001$), increased intake frequency of fruit and vegetables ($p=0.049$), reduction in salt and sugary beverages ($p\leq0.042$) and reductions in systolic blood pressure (BP) (-3.68 mmHg), diastolic BP (-3.54 mm Hg) and percentage body fat (-2.13%) ($p\leq0.020$) when compared to the control group. The SPANS appeared to be efficacious in improving PA and dietary behaviours, reducing BP and percentage body fat among Singaporean women.

Keywords: Ageing, anthropometry, blood tests, dietary habits, health promotion, non-communicable diseases, physical activity, program ambassadors.

What We Already Know

- Singaporean women aged over 50 years report high levels of leisure-time physical inactivity and less than half meet the recommended intake for fruit and vegetables.

- There is a scarcity of culturally relevant evidence-based physical activity (PA) and nutrition interventions for Asian countries.
- Innovative strategies are needed to help Singaporean women (>50 years) adopt health-enhancing nutrition and physical activity behaviours.

What This Article Adds

- To our knowledge, this is the first randomised controlled trial to determine the impact of a 6-month community-based PA and nutrition intervention for Singaporean women aged over 50 years.
- There were significant increases in PA levels (moderate, vigorous, total) and improvements in frequency of intake for fruit, vegetables, salty sauce and sugary beverages.
- Recreational centres located below high-rise government housing provide an accessible local space to recruit older women and conduct physical activity and nutrition behavioural interventions.
- This successful intervention appears to be culturally appropriate for older Singaporean women.

Introduction

In Singapore, women aged over 50 years self-reported high levels of leisure-time physical inactivity (72%) and a high intake of saturated fat (67%), sugary beverages (41%) in 2010.[1,2] Moreover, less than half of these women met the recommended serving guidelines for vegetables (26%) and fruit (34%). Due to these poor lifestyle practices, metabolic risk factors such as high blood pressure (BP), fasting blood glucose (BG) levels and waist-hip ratio (WHR) are highly prevalent among these women.[2]

Evidence-based physical activity (PA) and nutrition interventions are well-established for Western populations but there is a scarcity of culturally relevant interventions for non-communicable diseases (NCD) prevention programs in Asian countries.[3-6] Considering Singapore's ageing population and the associated increase in NCDs, innovative strategies to help women adopt healthy lifestyles are required. Despite the Singapore government being committed to improving community health and addressing the risk factors for NCDs, targeted programs for women's health remain limited.[7]

Recreational centres (RCs) are public facilities located below high-rise government housing, where 80% of Singaporeans live.[8] Building healthier communities through facilities such as the RCs can create viable and convenient environments to initiate health-promoting opportunities for these women. Therefore, this study examined the effectiveness of a 6-month community-based intervention to improve the health behaviours (PA and diet), BP, anthropometric and blood parameter outcomes among Singaporean women aged 50 years and over in RCs.

Methods

Study design

Ethics approval was obtained for the 6-month community-based PA and nutrition cluster randomised controlled trial (RCT) from the Curtin University Human Research Ethics Committee. The Singapore Physical Activity and Nutrition Study (SPANS) protocol and design have been described in detail previously.[9] The screening, recruitment and intervention period was staggered over 18 months, from October 2016 to March 2018, and post-test evaluation was completed in April 2018. The intervention was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) Statement;

see Supplementary File 1 (CONSORT flow diagram) and Supplementary File 2 (CONSORT checklists).[10]

Participants

Following the research protocol, 61 RCs (intervention N=31; control N=30) located in five Singaporean geographical districts were randomly selected using computer-generated random numbers by the principal investigator (PI).[9] There was a minimum separation distance of four kilometres to avoid the possibility of contamination between the two groups. Of the 61 RC managers who were invited to the study, only 26 [intervention (N=14) or control (N=12)] agreed to be involved in the study. For the intervention sites, the trained program ambassadors (final-year nutrition, sports and wellness students, qualified nutritionists and a certified fitness instructor) carried out the pre- and post-test assessment and the SPANS intervention. While at the control sites, the program ambassadors conducted only the pre- and post-assessment.

Of those who were invited, 682 (intervention, n=351; control, n=331) agreed to participate and met the selection criteria: a) female, aged 50 years and over; b) did not meet the recommended PA guidelines (less than 150 minutes of self-reported moderate-intensity PA per week); c) absence of a medical condition or poor mobility that prohibited their involvement in a PA program and d) not currently enrolled in other nutrition and PA research studies. All eligible participants (n=682) who met the above criteria completed the baseline assessment that included the Global PA Questionnaire-Short Form (GPAQ-SF).[11] Participants on medications (e.g., glucose-lowering drugs) were eligible to participate in the intervention.

Procedure

Program ambassadors frequently liaised with the 26 RC managers to distribute the recruitment flyers and intervention resources and answered any enquiries related to the intervention. The flyers were promoted by the respective RC managers during the centres' activities and given to female patrons that meet the selection criteria. Recruitment of participants was conducted through program flyers placed on the RCs' bulletin boards. Contact details of interested participants were recorded by the RC managers and provided to the program ambassadors. Participants were then contacted to assess their eligibility and informed of the study's purpose, confidentiality issues and that they were free to withdraw at any stage. All participants were blinded to their intervention status. Only the program ambassadors and PI were aware of the group allocation.

Intervention

Social Cognitive Theory[12] complemented by Motivational Interviewing (MI) guided the development of SPANS and delivery of the program's educational and skill sessions, along with telephone support. Provision of feedback, reinforcement, skill-building, practice and goal-setting were program strategies to support positive behaviour change. The SPANS program was developed by examining previously successful PA and nutrition strategies used in targeting older adults,[3-6] pilot-testing resources and conducting formative evaluation with the target group. Program ambassadors introduced the program and also distributed and explained printed resources (health calendar, PA and nutrition booklets and recipe booklet) based on the Singaporean PA and dietary guidelines[13,14] to the intervention participants at the RCs. Participants were encouraged to engage in 150 minutes of moderate-intensity PA weekly and record their PA frequency and duration in the health calendar. They also attended nutrition workshops, telephone dietary counselling sessions and low-intensity bi-weekly PA

classes and they received text messages, telephone follow-ups and feedback from the program ambassadors. The components of the intervention were designed to motivate participants to stay physically active and maintain a healthy diet as a means of reducing risk factors of chronic diseases. Positive behavioural reinforcements through regular encouragement and feedback were facilitated by RC managers and program ambassadors. Furthermore, the interventions were conducted in RCs within the participants' neighbourhoods to minimise participant burden. In contrast, the control group participants only received a falls prevention booklet. Intervention strategies and resources have previously been explained in detail.[9]

Measurement instruments

A structured bilingual (English and Chinese) questionnaire was administrated face-to-face by the program ambassadors at baseline and post-intervention to gather information on demographic and health characteristics. Details of the measurement instruments and outcome variables have been described elsewhere.[9]

Primary outcome variables

The *GPAQ-SF,* developed by the World Health Organization (WHO), has been validated for Singaporean adults.[11] It was used to measure self-reported PA (moderate-vigorous PA, walk and cycle PA and total PA) and sitting time.

Accelerometers [*ActiGraph GT3X* (ActiGraph, Pensacola, Florida, USA)] objectively measured the duration (minutes daily) and intensity (moderate-vigorous) of PA including sedentary behaviour (sitting time).[15] Acceleration was accumulated from three axes (vertical, mediolateral, anteroposterior) and combined into a vector magnitude score.[16] Participants

with ≤4 days of 10 hours daily wear-time (excluding water-based activities) were included in the analysis. Non-wear-time was filtered from the raw data using the Troiano algorithm, based on ≥60 consecutive minutes of zero counts, with an allowance of up to 2 minutes of counts from 1 to 100.[16,17] Interested participants were given an information sheet on the accelerometer and the device was fitted to their right hip. Accelerometry data were collected and downloaded using 10-second epochs. Using the ActiLife 6 software (ActiGraph, Pensacola, Florida, USA), the Freedson cut-off points for adults' estimated sedentary behaviour [<100 counts per minute (cpm)], moderate-intensity PA (1952-5724 cpm) and vigorous-intensity PA (5725-9498 cpm).[16,17]

A modified STEPwise approach to Surveillance *dietary behaviour questionnaire,* developed by the WHO, was used to assess the frequent intake of fat, salt, sugary beverages, fruit and vegetables.[18]

Fasting *blood samples* were collected to determine fasting BG, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), non-HDL-C, cholesterol ratio and triglyceride (TG) levels. They were measured, calculated and compiled into reports at approved laboratories under the Singaporean Ministry of Health guidelines.[19,20]

Secondary outcome variables

Trained program ambassadors followed standard protocols to measure: a) weight using a calibrated electronic scale and recorded to the nearest 0.01 kg; b) height measured barefoot with a portable stadiometer to the nearest 0.1 cm and Body Mass Index (BMI) calculated by dividing weight by the square of height (kg/m^2);[21] c) percentage body fat taken without shoes

and socks by an Endo Body Fat Composition Analyser E-DBS908;[22] d) waist circumference (WC) using a non-stretch tape, standing up at the midway level between the lowest rib margin and the iliac crest and recorded to the nearest 0.1 cm; e) hip circumference (HC) at the widest circumference at the level of the symphysis pubis and gluteus maximus;[5] and f) WHR calculated by dividing WC by HC. Systolic and diastolic BP were measured three times using an Omron electronic sphygmomanometer on the participant's upper arm at one-minute intervals while seated and the mean of the readings was recorded.[3]

Statistical Analysis

Descriptive statistics contrasted the baseline characteristics of the intervention and control groups. Comparisons between the groups were made across the baseline and post-test time points using Chi-square tests for dichotomous and categorical outcomes, and independent t-tests and paired t-tests for continuous outcomes. For variables with skewed distributions [(moderate, total, walk and cycle) PA, sitting time, BG and TG], Mann-Whitney U test and Wilcoxon signed-rank test were applied instead.

To confirm any apparent association from the univariate analysis and to accommodate the inherent correlation of observations due to participants being nested within RCs, generalised estimating equation (GEE) models with exchangeable correlation structure were fitted to compare the outcome variables between the two groups from baseline to post-intervention. The GEEs provided robust standard errors for the regression coefficients to adjust for the intra-cluster correlation, while accounting for the baseline magnitude of the measures and the effects of potential confounders (age, ethnicity, educational level, marital status, housing type, health conditions, medication usage and clustering effect). These covariates were specified in the study protocol[9] and based upon comparable PA and nutrition interventions[3-6]

for older adults. All statistical analyses were performed at an individual level using Statistical Package for the Social Science version 25.[23] The sample size requirement of 240 participants per group[9] was met in this study, enabling 80% statistical power to detect a medium effect size of 10% improvement in PA prevalence by intervention participants relative to the control at a significance level of 5%.

Accelerometry data were obtained from the intervention group only. Because most participants did not engage in vigorous PA, this variable was recoded into binary form to specify participation status (yes, no). Moderate PA, total PA, walk and cycle PA and sitting time remained as continuous variables. For dietary behaviour outcomes, fruit and vegetable consumption was classified as 'frequent intake' if at least two servings were eaten daily, whereas salt and salty sauce consumption were classified as 'frequent intake' if taken at least once per week. Sugary beverage and fatty food intake were classified as 'frequent intake' if taken more than three times per week. Binary outcomes, such as vigorous PA, frequent intakes of fruits, vegetables, salt and salty sauce, sugary beverage and fatty food intake, were analysed using logistic GEE models, while normal GEE models with identify links and gamma GEE models with log links were applied to continuous outcomes exhibiting symmetric/normal and skewed empirical distributions, respectively.

Results

The final sample included 295/351 intervention (84%) and 285/331 control (86%) participants. The number of participants lost was n=56 for the intervention group and n=46 for the control group (see Supplementary File 1-CONSORT figure for more details). In addition, there were no missing data for all outcomes and covariates. There were no significant differences in the baseline characteristics between the intervention and control

groups, except for age (p=0.005). The intervention participants (mean age 64.5 years, standard deviation (SD)=7.9) were slightly older than the control group (mean age 61.6 years, SD=6.9). Most participants were of Chinese descent (95.3%), completed secondary school education (54.3%), were married (76.3%) and had existing health conditions (61.2%), see Table 1.

Table 1

Baseline characteristics of intervention and control group participants (n=580)

Variables	Intervention group (n = 295)	Control group (n = 285)	p value[a]
Age: mean (SD)	64.5 (7.9)	61.6 (6.9)	0.005
50-55	50 (16.9%)	59 (20.7%)	
56-62	74 (25.1%)	99 (34.7%)	
≥63	171 (58.0%)	127 (44.6%)	
Ethnicity			0.495
Chinese	283 (95.9%)	270 (94.7%)	
Malay, Indian and others	12 (4.1%)	15 (5.3%)	
Education Level			0.283
Primary school / no education	66 (22.4%)	80 (28.1%)	
High / secondary school	167 (56.6%)	148 (51.9%)	
Diploma, university and above	62 (21%)	57 (20.0%)	
Marital Status			0.184
Married	218 (73.9%)	224 (78.6%)	
Widowed, divorced or single	77 (26.1%)	61 (21.4%)	
Housing type			0.522
1-3 rooms	82 (27.8%)	68 (23.9%)	
4 rooms	89 (30.2%)	87 (30.5%)	
5 rooms and others[b]	124 (42.0%)	130 (45.6%)	
Health condition			0.051
No	103 (34.9%)	122 (42.8%)	
Yes[c]	192 (65.1%)	163 (57.2%)	
Medication usage			
No	155 (52.5%)	166 (58.2%)	
Blood pressure	49 (16.6%)	44 (15.4%)	

Variables	Intervention group ($n = 295$)	Control group ($n = 285$)	p value[a]
Cholesterol	76 (25.8%)	70 (24.6%)	0.126
Others[d]	15 (5.1%)	5 (1.8%)	

[a] Chi-square test or independent t-test between intervention and control groups.

[b] Executive flat (public housing at 130 sqm[2)], Housing and Urban Development Corporation flats (hybrids of public and private properties), condominium (private housing with recreational facilities), and landed properties (e.g. a semi-detached house, terraced home, townhouse, shophouse or bungalow.

[c] Heart disease, stroke, high blood pressure, high cholesterol, diabetes, cancer, osteoporosis, arthritis, and others.

[d] Medication for cardiovascular disease, blood clotting disorder, asthma, thyroid, osteoporosis, diabetes, cancer, and Parkinson's disease.

SD: standard deviation.

There were no significant differences in self-reported PA behaviours at baseline between the intervention and control groups. However, from baseline to post-test, significant increases were observed in the intervention group for moderate PA [65.2 metabolic equivalent of task (MET) mins per week, $p<0.001$], total PA (1123.5 MET mins per week, $p<0.001$), walk and cycle PA (187.5 MET mins per week, $p=0.002$) and vigorous PA ($p<0.001$), while sitting time did not change significantly ($p=0.872$). No significant changes in self-reported PA behaviours were observed in the control group from baseline to post-test. At post-test, significant differences were observed between intervention and control groups for moderate PA ($p<0.001$), vigorous PA ($p<0.001$) and total PA ($p=0.004$), but not for walk and cycle PA ($p=0.558$) or sitting time ($p=0.574$); see Table 2. Accelerometry data for the self-selected intervention participants (n=65) from 10 RCs supported the findings of the aforementioned PA measures, with significant increases in moderate ($p<0.001$), total PA ($p=0.003$), but not for vigorous PA and sitting time between the two-time points; see Supplementary File 3.

There were no significant differences in measures of dietary behaviour between the control and intervention groups at baseline. At post-test, significant improvements were observed in the intervention group for the frequent intake of fruit ($p<0.001$), vegetables ($p=0.018$), salt

and salty sauce (p=0.031), and sugary beverages (p<0.001). But no differences were observed in the control group from baseline to post-test apart from a reduction in frequent intake of sugary beverages (p<0.001). At six-month post-test, statistically significant differences between the two groups were observed for frequent intake of fruit (p<0.001), vegetables (p=0.027), salt and salty sauce (p=0.026) and sugary beverages (p=0.04); see Table 2.

Table 2

Comparison of self-reported PA and dietary behaviour outcomes between intervention and control groups (n=580)

Outcomes	Intervention group (n = 295)		p value[a]	Control group (n = 285)		p value[b]	p value[c]	p value[d]
	Baseline Mean (SD) / n (%)	Post-test Mean (SD) / n (%)		Baseline Mean (SD) / n (%)	Post-test Mean (SD) / n (%)			
Moderate PA (MET mins/week) [e]	64.71 (54.46)	129.86 (150.07)	<0.001	62.78 (54.62)	54.40 (64.08)	0.064	0.522	<0.001
Vigorous PA n (%)	18 (6.1%)	69 (23.4%)	<0.001	9 (3.2%)	10 (3.5%)	0.815	0.093	<0.001
Total PA (MET mins /week) [e]	2767.43 (3254.51)	3890.93 (3671.38)	<0.001	3134.62 (3230.52)	3290.13 (3361.10)	0.528	0.057	0.004
Walk and Cycle PA (MET mins/week) [e]	911.33 (1588.98)	1098.86 (1934.26)	0.002	821.52 (1154.30)	842.44 (1137.39)	0.428	0.470	0.558
Sitting time (mins/week) [e]	1290.85 (978.18)	1243.04 (783.63)	0.872	1279.16 (938.54)	1334.053 (904.33)	0.071	0.871	0.574
Frequent fruits intake [f]	123 (41.7%)	171 (58%)	<0.001	128 (44.9%)	122 (42.8%)	0.613	0.434	<0.001
Frequent vegetables intake [f]	169 (57.3%)	197 (66.8%)	0.018	149 (52.3%)	165 (57.9%)	0.178	0.226	0.027
Frequent salt and salty sauce intake [g]	230 (78%)	207 (70.2%)	0.031	214 (75.1%)	223 (78.2%)	0.323	0.413	0.026
Frequent sugary beverages intake [h]	55 (18.6%)	28 (9.5%)	<0.001	53 (18.6%)	43 (15.1%)	<0.001	0.988	0.040
Frequent fat Intake [h]	90 (30.5%)	80 (27.1%)	0.375	88 (30.9%)	80 (28.1%)	0.383	0.923	0.798

[a] Wilcoxon Signed-Rank test or Chi-square test between baseline and post-test for the intervention group.

[b] Wilcoxon Signed-Rank test or Chi-square test between baseline and post-test for the control group.

[c] Mann-Whitney U test or Chi-square test between intervention and control group at baseline.

[d] Mann-Whitney *U* test or Chi-square test between intervention and control group at post-test.

[e] Non-parametric tests applied.

[f] At least two servings per day.

[g] At least once per week.

[h] More than three times per week.

MET: Metabolic Equivalent of Task, PA: Physical Activity, SD: Standard Deviation.

The diastolic and systolic BP in the intervention participants were found to be significantly improved post-intervention, with decreases of 3.54 and 3.68 mm Hg, respectively ($p<0.001$). Conversely, the BP of participants in the control group slightly increased (i.e., diastolic by 1.18 mm Hg, $p=0.034$ and systolic by 1.26 mm Hg, p=0.184); see Table 3.

The intervention group also exhibited small but statistically significant reductions in weight (0.57 kg), BMI (0.24 kg/m^2) and percentage body fat (2.13%) ($p<0.001$), whereas these parameters were unaltered in the control group. Significant improvements were also observed in the intervention group for measures of central adiposity (WC, HC, WHR). However, similar improvements were observed in the control group for WC and HC; see Table 3. Fasting BG concentration significantly decreased during the study in both intervention (0.11 mM, $p=0.027$) and control (0.19 mM, $p<0.001$) groups, whereas their lipid profiles remained essentially unchanged except for a marginal increase in TC concentration in the control group (by 0.1 mM, $p=0.041$); see Table 3.

Table 3

Comparison of blood pressure, anthropometry and blood parameter outcomes between intervention and control groups (n=580)

Outcomes	Intervention group ($n = 295$)		p value[a]	Control group ($n = 285$)		p value[b]	p value[c]	p value[d]
	Baseline Mean (SD)	Post-test Mean (SD)		Baseline Mean (SD)	Post-test Mean (SD)			
Systolic blood pressure (mmHg)	132.25 (18.43)	128.57 (18.26)	<0.001	125.98 (18.0711)	127.24 (17.52)	0.184	<0.001	0.373
Diastolic blood pressure (mmHg)	78.41 (10.)	74.87 (9.60)	<0.001	75.68 (10.31)	76.86 (10.15)	0.034	0.001	0.015
Waist Circumference (cm)	83.54 (9.45)	81.84 (9.26)	<0.001	82.17 (9.35)	81.03 (9.84)	0.003	0.080	0.306
Hip Circumference (cm)	96.54 (7.61)	95.54 (7.44)	<0.001	95.43 (7.51)	94.25 (7.97)	<0.001	0.078	0.044
Waist-Hip Ratio	0.87 (0.07)	0.86 (0.07)	0.010	0.86 (0.07)	0.86 (0.07)	0.737	0.407	0.562
Weight (kg)	56.80 (9.21)	56.23 (9.11)	<0.001	55.49 (8.91)	55.44 (8.94)	0.770	0.082	0.293
Body Mass Index (kg/m^2)	23.35 (3.48)	23.11 (3.43)	<0.001	23.02 (3.42)	23.00 (3.45)	0.789	0.249	0.696
Percentage body fat (%)	32.71 (8.05)	30.58 (8.03)	<0.001	29.93 (8.65)	30.23 (8.50)	0.282	<0.001	0.612
Blood glucose (mM) [e]	5.21 (0.99)	5.10 (0.96)	0.027	5.14 (0.85)	4.95 (0.91)	<0.001	0.148	0.004
Total Cholesterol (mM)	5.34 (0.97)	5.35 (1.06)	0.828	5.48 (0.90)	5.58 (0.99)	0.041	0.070	0.009
Low-Density Lipoprotein Cholesterol (mM)	3.08 (0.86)	3.09 (0.91)	0.782	3.30 (0.83)	3.29 (0.93)	0.648	0.001	0.011
Non-High-Density Lipoprotein Cholesterol (mM)	3.66 (0.92)	3.67 (1)	0.975	3.77 (0.92)	3.84 (1)	0.068	0.178	0.031
Cholesterol ratio	3.32 (0.87)	3.33 (0.89)	0.727	3.37 (0.93)	3.39 (0.94)	0.606	0.442	0.422
Triglyceride (mM) [e]	1.28 (0.60)	1.28 (0.58)	0.393	1.23 (0.56)	1.26 (0.62)	0.699	0.281	0.323
High-Density Lipoprotein Cholesterol (mM)	1.69 (0.44)	1.69 (0.45)	0.780	1.71 (0.44)	1.73 (0.42)	0.126	0.548	0.208

[a] Paired t-test between baseline and post-test for the intervention group.

[b] Paired t-test between baseline and post-test for the control group.

[c] Independent t-test between intervention and control group at baseline.

[d] Independent t-test between intervention and control group at post-test.

[e] Non-parametric tests applied.

SD: Standard Deviation.

After controlling for confounders and the inherent clustering, GEE analyses confirmed significant increases for moderate PA ($p<0.001$), vigorous PA ($p<0.001$) and total PA ($p<0.001$) but not for walk and cycle PA ($p=0.454$) or sitting time ($p=0.190$) by the intervention group relative to the control group; see Supplementary Files 4 and 5. As for BP, anthropometry and blood parameter outcomes, significant reductions (baseline to post-intervention) in the intervention group relative to the control group were only observed in systolic BP ($p=0.020$), diastolic BP ($p=0.001$) and percentage body fat ($p<0.001$). Logistic GEE analyses demonstrated significant improvements in the frequent intake of fruit ($p=0.001$), vegetables ($p=0.049$), salt and salty sauce ($p=0.042$) and sugary beverages ($p=0.019$) by the intervention group relative to the control group (see Supplementary File 5). Moreover, the magnitudes of the estimated intra-cluster correlations for the various continuous and binary outcomes were all small (<0.07), indicating minimal effect due to the RC clusters.

Discussion

The SPANS intervention had a low attrition rate (15%), which may have been due to its acceptability and accessibility for the Singaporean women aged above 50 years.[24] This compared favourably with similar PA and nutrition RCTs for older adults (19-22%).[3-6] The GEE analyses confirmed significant improvements in behavioural and health outcomes between the intervention and control groups. Such improvements were displayed in moderate to vigorous PA and total PA compared to the control group. These findings were supported by objectively measured accelerometry measurements (except for vigorous PA) taken from a sub-sample of the intervention participants (n=65). Moreover, there were improvements in dietary behaviour (increased frequent intake of fruit and vegetables, reduced frequent intake of salt and salty sauce and sugary beverages). Furthermore, systolic BP, diastolic BP and percentage body

fat were significantly reduced over the 6-month period. These findings are similar to those reported in a limited number of primary prevention initiatives conducted in other areas of Asia, showing that culturally appropriate PA and nutrition interventions can effectively improve behaviour and metabolic risk factors in older populations.[6,25,26]

Other anthropometric measures and the lipid profiles were not significantly altered relative to the control group. However, within-group improvements for the intervention group were observed for WC, HC, WHR, weight and BMI. These improvements are consistent with those observed in other PA and nutrition intervention studies of similar duration.[3-6] However, no statistically significant within- or between-group changes in the fasting lipid profile were found. This may be related to the dose of PA performed in the SPANS intervention with a short PA intervention period (<60 minutes) and insufficient PA volume and frequency,[26] perhaps indicating a need for higher-intensity and longer-duration interventions. A systematic review of behavioural lifestyle RCTs also reported higher-intensity behavioural PA and dietary counselling exhibited greater improvements in anthropometric and metabolic risk factors.[27]

Self-reported walk and cycle PA were not significantly different between groups at post-test; possibly due to a high percentage of intervention and control participants (89%) already walking or cycling at baseline. A similar non-significant result was observed in a study, where 78% of the Japanese participants were already walking or doing other PA at baseline.[28] Further increases in these modes of transport might not be feasible due to the densely built environment, hot-rainy weather, and a lack of cycling infrastructure, as reflected in a qualitative Singaporean study.[29] Moreover, there was no reduction in sitting time, which has also been reported in similar studies.[3,5] This issue is deserving of attention through the trialling of future strategies to encourage less sitting time.

Self-selection bias was unavoidable but was minimised through allocation concealment throughout the trial. Although in hindsight, to ensure a more homogenous study group, the recruitment age could be restricted to less than 70. Self-reported PA and dietary practices might have introduced recall and response bias. However, participants were blinded to their group allocation, which reduced any differential in reporting of health behaviours, with the expectation that inaccuracies would be similar across both groups. Additionally, the program ambassadors and the PI in charge of data collection were not blinded, which may have introduced some bias. Nevertheless, the positive PA and dietary behaviours and improvements in BP and percentage body fat offer a potential model for implementing PA and dietary intervention program with this Singaporean population. Since NCDs are largely preventable, there is an urgency to prioritise and investigate the applicability of such long-term primary interventions to address chronic diseases at a national level in this Asian population.

Limitations

The study was restricted to women aged 50 years and above. However, future research could be extended to Singaporean men to increase the study's generalisability. Due to resource constraints, the study was conducted only for six months. A longer follow-up assessment period could be considered to examine program sustainability and the effectiveness of behavioural changes over time. Furthermore, the sub-sample of the self-selected intervention participants who wore the accelerometers might have been more committed to PA, which could bias the PA outcomes. Although these devices were limited in number due to budgetary constraints, they provided objective measurements of the PA outcomes.

Conclusions

The SPANS program was associated with improvements in PA and dietary behaviours, as well as reductions in percentage body fat, systolic and diastolic BP, in the intervention participants when compared to the control participants over the 6-month intervention period. Given the high prevalence of NCD risk factors among Singaporean older women, adoption of desirable health behaviours through culturally appropriate lifestyle interventions, such as SPANS within supportive environments, could be an effective strategy to reduce the risk of NCDs and optimise the health status of the 'at risk' insufficiently active ageing populations.

Supplementary files

Supplementary file 1- CONSORT figure

Supplementary file 2- CONSORT checklist

Supplementary file 3- Accelerometry data for a sub-sample of the self-selected intervention participants (n=65) from 10 RCs

Supplementary file 4- Generalised estimating equations analyses of continuous outcomes between the two groups from baseline to post-intervention (n=580)

Supplementary file 5- Generalised estimating equations analyses of binary outcomes between the two groups from baseline to post-intervention (n=580)

Abbreviations

BG: Blood glucose, BMI: Body Mass Index, BP: Blood pressure, CONSORT: Consolidated Standards of Reporting Trials, CPM: Counts per minute, GEE: Generalised estimating equations, GPAQ-SF: Global Physical Activity Questionnaire-Short Form, HDL-C: High-density lipoprotein cholesterol, HC: Hip circumference, LDL-C: Low-density lipoprotein cholesterol, MET: Metabolic Equivalent of Task, MI: Motivational interviewing, NCDs: Non-communicable diseases, PA: Physical activity, PI: Principal Investigator, RC: Recreational centre, RCT: Randomised controlled trial, SD: Standard deviation, SPANS:

Singapore Physical Activity and Nutrition Study, TC: Total cholesterol, TG: Triglyceride, WC: Waist circumference, WHO: World Health Organization, WHR: Waist-hip ratio.

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Chapter 5
Discussion

This thesis describes the development, implementation and evaluation of the Singapore Physical Activity and Nutrition Study (SPANS) in women aged ≥50 years old attending recreational centres (RC). The results displayed improvements in physical activity (PA), dietary behaviours, blood pressure (BP) and body fat percentage. To support positive behavioural changes and health outcomes, periodically upgrading the RCs' facilities and activities is deemed necessary to stay current with the changing demands and interests of the participants. A comprehensive process evaluation is reported to explain the links between intervention strategies and outcomes for this high-risk target group. This section reflects on the study objectives and elaborates on the strengths and limitations that were discussed in the four publications presented as part of this thesis.

5.1 Reflection on the study objectives

5.1.1 Objective 1

The purpose of objective 1 was to design and implement a six-month cluster randomised controlled trial (RCT) of a community-based intervention to improve PA and dietary behaviours of Singaporean women aged ≥50 years old attending RCs (see **Publication 1**, Appendix B). Behavioural change interventions have been extensively explored in Western nations to address risk factors of non-communicable diseases (NCD), notably, cardiovascular disease (CVD), cancer and type 2 diabetes (T2D) but are under-researched in an Asian context. Due to rapidly ageing populations practising habitual physical inactivity and poor diets in Asia (WHO, 2017b; Yiengprugsawan et al., 2016), the investment in PA and dietary interventions is necessary to tackle the high NCD burden as advocated by the World Health Organization (WHO). As highlighted by Ang et al. (2019), interventions targeting PA and healthy eating practices are fundamental strategies needed in ongoing national efforts to prevent NCDs in Singapore. Low PA levels, poor dietary habits and high prevalence of metabolic risk factors of NCDs among urbanised Singaporean women aged ≥50 years old make them a high-risk group in need of such behavioural interventions (Wong et al., 2018). The SPANS is the first behavioural change RCT ever undertaken on insufficiently active Singaporean women, according

to our literature review and study findings are potentially applicable for NCD prevention in the target group. PA and dietary interventions are well-established as improving behavioural and metabolic risk factors of NCDs, notably in older adults. Risk factors such as hypertension, hyperglycaemia, overweight and obesity and hyperlipidaemia were reduced in studies lasting from 6 to 12 months in Canada, United States (US), United Kingdom (UK), Europe and Australia (Borek et al., 2018; Samdal et al., 2017). In contrast, few behavioural change interventions have displayed improvements in metabolic risk factors of NCDs in Asian adults aged ≥50 years old (Ibrahim et al., 2016; Mohd Zaki et al., 2018; Wu et al., 2019). Given the scarcity of such interventions, more research targeting high-risk older Asian adults should be conducted to prevent and manage NCDs (Brand et al., 2014; WHO, 2017b). Considering the shortage of robust literature research in Asian women aged ≥50 years old, the SPANS addresses this knowledge gap by investigating the effectiveness of behavioural change intervention in improving PA and dietary behaviours. This approach may consequently alleviate NCD risk factors among Singaporean women.

PA and dietary interventions have used a range of strategies such as behavioural change techniques (BCT), motivational interviewing (MI) techniques and motivators to encourage positive health behaviours. For instance, BCTs such as goal-setting, self-monitoring and feedback promoted participants' engagement and program adherence when facilitated by frequent contacts with professionals trained in MI techniques (Bassi et al., 2014; Samdal et al., 2017). Moreover, MI techniques and motivators are key strategies employed in PA and nutrition interventions to address metabolic risk factors of NCDs (Lara et al., 2014; Zubala et al., 2017). However, behavioural changes are challenging to initiate and maintain. Therefore, the current SPANS could be further refined by enhancing participants' self-efficacy towards healthy living through self-monitoring and rewarding positive behaviours using real-time feedback (Sullivan & Lachman, 2017). By way of example, future research should use the Fitbits and the Healthy 365 mobile app developed by the Health Promotion Board (HPB) (Yao et al., 2019) to motivate older inactive adults and reward them for their positive PA (increasing step counts) and dietary (healthy shopping and dining out) practices. Considering the high incidence of chronic diseases among older Singaporean women, it is also worthwhile to determine the

most effective strategy to foster and sustain positive PA and dietary practices in behavioural change interventions.

Besides the aforementioned strategies, Social Cognitive Theory (SCT) and the Socio-Ecological Model (SEM) account for socio-environmental factors that shape PA and dietary choices in older adults. For example, the key construct of SCT (self-efficacy) has evoked positive PA and dietary modifications among adults (mean age 59 years) (Gourlan et al., 2016; Stacey et al., 2015). Related to this, the SEM sustains behavioural changes by considering the individual, social and environmental contexts (Golden & Earp, 2012). The principles of SEM align with SCT constructs in creating health-promoting environments conducive to the adoption of PA and dietary behaviours. Indeed, the SCT-based SPANS, when guided by the SEM framework, could facilitate PA and dietary changes among older adults at supportive RC settings, thus ultimately improving their health outcomes.

5.1.2 Objective 2

Objective 2 examined the facilities and activities of RCs to support PA and dietary practices for the target group **(Publication 2**, Appendix B). RCs were community venues built under the public housing estates to promote neighbourliness and racial harmony amongst Singapore residents (People's Association, 2019). Although the RCs' environment may support PA and dietary behaviours in older adults, research on the facilities and activities of such settings to facilitate positive behavioural changes is lacking (Wong et al., 2019). For this reason, both quantitative (audit assessment of the built RCs) and qualitative (interview of RCs' participants on facilities and activities) data were collected to identify strategies for improving participants' PA and dietary behaviours. Findings from the RCs' audit research reported on the appropriateness of the RCs for supporting behavioural changes in Singaporean women ≥50 years old. Firstly, most centres' facilities and activities received government funding and support (80%). Secondly, they are utilised weekly by the target group (82%). Lastly, they are ubiquitous within all Singapore neighbourhood districts with proximity to their homes (7-minute walk) (Wong et al., 2019). Indeed, these facilities align well with the government's healthy ageing initiatives (MOH, 2016b) in providing PA and nutrition opportunities close to their

residences. This study provides the first report that explores how the built and social environment of RCs can facilitate PA and dietary behaviours for older participants.

Despite the popularity of the RCs among older women, the quantitative results found that the built facilities and activities of most centres were geared towards the promotion of PA levels compared to healthy eating practices. For example, most RCs (≤ 83%) had exterior facilities such as parks, exercise stations, basketball/badminton courts and bicycle racks; 87% of them offered PA activities up to eight times per month. Conversely, fewer centres (≤ 46%) had vegetable/fruit/spice gardens, kitchens with cooking appliances, vending machines with healthy foods and drinks; 60% of them offered nutrition activities only once per month. Similar findings were reported in a preliminary study, which revealed that most RCs prioritised PA over nutrition (Kailasam, Hsann, Vankayalapati, & Yang, 2017). However, that pilot study was undertaken at only seven RCs located in the western region of Singapore. Future studies should include larger sample sizes and be conducted in all regions to validate the findings. Considering the space constraints of RCs (Wong et al., 2019) and reported intrinsic motivators (e.g., health benefits and social bonding) that increase the SPANS's engagement (Wong, Lee, James, & Jancey, 2020), outdoor facilities and group-based activities should be targeted in future interventions to promote PA and healthy eating practices.

Results from the qualitative interviews with RC participants suggested the use of neighbourhood parks to support social interactions that may lead to positive PA behaviours. This suggestion is noteworthy since most RCs (83%) are located close to surrounding parks (within 400 metres). Future studies should work with the Sports Singapore to explore how to make use of underutilised park areas to create more PA opportunities. Sports Singapore is a government organisation that empowers Singaporeans to live better through sports and helps to bring sports into their lives (Sports Singapore, 2020). Moreover, various studies have demonstrated that aesthetically pleasant parks provided socialising opportunities that stimulate PA behaviours in adults aged ≥50 years old (Costigan et al., 2017; Salvo et al., 2018; Wong et al., 2019). Importantly, parks are advocated as low-cost settings to promote neighbourhood ties and enable positive modelling of PA practices (Institute Golden Gate National Parks Conservancy, 2019). In Singapore, adults aged >50 years old

expressed interest in parks activities such as qigong, tai chi and yoga (Léonie et al., 2019). A recent six-month RCT park intervention consisting of weekly PA sessions and phone counselling displayed increased recreational PA and time spent in the park for the intervention participants (mean age 51 years) compared to the control participants (Müller-Riemenschneider et al., 2020). In addition, training of peer-aged RC volunteers to be walking leaders to establish groups and buddy systems improved PA behaviours (Prins, Kamphuis, de Graaf, Oenema, & van Lenthe, 2016). Future studies should involve close collaboration between RCs' managers and participants, health practitioners as well as park and recreation planners to design park activities that improve communal networking and increase PA levels.

On the other hand, the qualitative data also revealed participants' interest in community gardens that may improve their social engagement in dietary practices. Supported by various studies, gardening has increased the consumption of fruit and vegetables among gardeners (Algert et al., 2016; Gray et al., 2014; Soga, Gaston, & Yamaura, 2017). In Singapore, a three-month RCT illustrated that gardening improves social connectedness in Singaporean adults aged >60 years old (Sia et al., 2018). Nutritional benefits gained from gardening initiatives remain to be investigated. Considering the dietary benefits of gardening and the fact that most RCs (72%) have unused gardening plots (Wong et al., 2019), the National Park of Singapore could be engaged by RC managers to impart horticultural skills to participants interested in cultivating fruit, vegetable, spice and herb gardens. The National Park of Singapore is a government organisation that has partnered with the community to promote greenery and nature as a recreational activity (National Parks, 2019). Fresh garden produce could be used in the RCs' activities like culinary demonstrations, for example, supplemented with nutritious recipes, to reinforce healthy eating practices.

5.1.3 Objective 3

Objective 3 evaluated the appropriateness and acceptability of the intervention strategies and resources for the target group (see **Publication 3**, Appendix B). Process evaluation has been increasingly recognised as a beneficial component in health interventions; it is of particular importance to understand the implementation of strategies and resources in the 'niche' RC setting to guide behavioural

improvements. However, a paucity of robust process evaluation in PA and nutrition behavioural change studies in Asia exists (Chapman et al., 2013; Liu et al., 2019), making it difficult to replicate an effective intervention. Although such evaluations are integral to increase program transferability, they are often under-reported and of unacceptable quality. For these reasons, the SPANS included a comprehensive process evaluation framework adapted from Saunders, Evans, and Joshi (2005) to systematically validate the desired effective intervention components. Clearly, process evaluation is beneficial for gathering feedback and suggestions from the RCs' participants and refining the program, strategies and resources to positively improve PA and dietary changes.

Regular feedback and program modification are valuable at the early stages of the process evaluation to address program recruitment, participation and retention. For instance, accelerometry reports were provided to participants who requested them. The personalised feedback on their PA levels improved their compliance in wearing the accelerometer pre- and post-intervention. Another example is that the delivery of PA and dietary sessions at flexible times by bilingual program ambassadors increased program participation and retention. As supported by O'Hara et al. (2014), conducting early feedback provided useful insights into program context, impact and challenges that guided the implementation process. As a result, the SPANS reached and engaged the participants with high program fidelity. Moreover, its low attrition rate (16%) is comparable to other attrition rates of PA and nutrition studies on adults aged ≥50 years old at risk of CVD for 12–24 months duration (0%–60%) (Zhang et al., 2017) and overweight adults for 6–12 months duration (4%–59%) (Borek et al., 2018). Furthermore, reasons for program withdrawal, such as personal commitments and time conflicts, were similar to other PA and dietary interventions among older adults (Blackford et al., 2017; Burke, Jancey, et al., 2013; Tran, Jancey, et al., 2017). Since participants' needs change over time, iterative process evaluation is crucial for developing multiple approaches to maintain their preferences and interests. Reported intrinsic motivators such as enjoyment, health benefits and social bonding need to be considered in future programs (Wong, Lee, et al., 2020). For instance, the SPANS session can be made more enjoyable by providing childcare services to ease their duties as caretakers and PA sessions of lower intensity for adults aged >65 years old. Indeed, early initiation of process evaluation should address deterrents to program

challenges by developing practical strategies to justify and allocate resources in supporting program engagement and adherence.

The SPANS, when conducted by program ambassadors trained in MI techniques, provided tailored feedback that motivated the participants to adopt healthier diets and regular PA. Such techniques, when combined with face-to-face PA classes and nutrition workshops and phone dietary counselling sessions, achieved high program satisfaction ratings and were well received by the participants. According to Bock et al. (2014), group-based delivery sessions were effective in promoting social networks in a review of 17 community-based PA and nutrition studies. Moreover, interpersonal support and MI techniques used by program ambassadors drive positive PA and dietary maintenance (Hardcastle et al., 2013; Picorelli, Pereira, Pereira, Felício, & Sherrington, 2014). Future longer term research could explore if RC managers trained in BCTs or MI could motivate participants to maintain behavioural changes. However, the face-to-face delivery mode is resource-intensive and alternative ways are warranted. Since phone dietary counselling achieved the highest participation rates in the SPANS, it may be worthwhile to investigate low-cost interventions using free mobile phone apps like WhatsApp video calls in future studies. Overall, MI techniques delivered by trained program ambassadors via group-based workshops and individualised phone sessions supported participants' PA and dietary modifications.

Furthermore, appropriate health resources and motivators were pivotal strategies that could persuade behavioural changes in the SPANS participants. Indeed, tailored printed materials have been promising in motivating PA and dietary practices in older Asian adults (mean age 62 years) (Tran, Jancey, et al., 2017; Yoo et al., 2012). When culturally relevant, calendars and health booklets act as self-monitoring tools to strengthen participants' efficacy in monitoring their PA and dietary practices. Extrinsic motivators (e.g., supermarket vouchers) were recommended in the SPANS to increase participants' program engagement (Wong, Lee, et al., 2020). Sullivan and Lachman (2017) suggested adding feedback and rewards to increase healthy behaviours through the use of trackers and mobile phone apps to motivate inactive populations. A study reported that cash incentives increased moderate to vigorous PA levels among Singaporean working adults (mean age 36 years) using activity

trackers (Finkelstein et al., 2016) and are consistent with cash incentives to increase PA participation among inactive Singaporean adults >50 years old (Farooqui et al., 2014). However, such effects were not sustained 6 months after the incentives were discontinued. Longitudinal studies >6 months are needed to examine the feasibility of economic incentives in long-term behavioural change. Yao et al. (2019) recommended targeting Fitbits and Healthy 365 app at older inactive adults to increase their self-efficacy by rewarding their engagement in positive PA, shopping and dining practices as participants are extrinsically motivated to increase PA and dietary efforts in exchange for monetary rewards. However, these devices could be improved in future interventions by providing timely motivational messages and feedback on behaviour changes. It is to be noted, though, the app may not address the needs of older adults who do not own smartphones, while others may lack the knowledge and confidence to make effective use of such devices. More research can explore older Singaporean adults' perception of these tools in designing age-friendly resources that complement the SPANS. Overall, customising resources and rewards can increase the scalability of the SPANS to target behaviour changes in older adults.

5.1.4 Objective 4

Objective 4 assessed changes in PA, sedentary and dietary behaviours of the intervention group participants relative to the control group participants from pre- to post-test (see **Publication 4**, Appendix B). The improvements seen in the behavioural outcomes of the SPANS were validated via a process evaluation that reported intervention fidelity and program acceptability. These include improvements in dietary behaviours (reduced intake of salt and salty sauce and sugary beverages and increased intake of fruit, vegetables and wholegrains) and increased PA (moderate, vigorous and total) levels. Moreover, the accelerometry results for a sub-sample of self-selected intervention participants displayed significant increases in moderate and total PA levels. Indeed, these PA and dietary behaviour modifications in the SPANS were achieved by using MI techniques and BCTs for this high-risk target group. Similarly, such PA and dietary modifications were previously reported in other six-month behavioural interventions that engage in the usage of BCTs like goal-setting and MI techniques (Blackford, Jancey, Lee, James, Howat, et al., 2016; Burke, Lee, et al., 2013; Tran, James, et al., 2017; Yoo et al., 2012). Clearly, the findings from the process evaluation are critical in

determining intervention components that improved PA and dietary outcome measurements.

In contrast, significant improvements were not observed in the self-reported sedentary behaviour (SB) and walking and cycling PA among the intervention and control group participants. Although the accelerometry data does not measure walking and cycling PA levels, the data supported no significant changes in SB among the intervention group. The absence of changes in the walking and cycling PA, including SB, between the two groups, may be due to the over-reporting of the walking and cycling PA levels, under-reporting of SB and poor recall ability among the participants that limited the validity of the Global PA Questionnaire Short-Form (Cleland et al., 2014; Win et al., 2015). Nevertheless, this self-report tool was combined with objective measures of PA (accelerometers) to provide reliable and accurate measures of SB (Heesch et al., 2018). Considering the health benefits of walking and cycling PA (Rojas López & Wong, 2017) and breaking up sitting time (Patnode et al., 2017), more effective intervention strategies are required to address these activity gaps among inactive Singaporean women. For example, viable low-cost strategies could engage enthusiastic peer-aged volunteers to champion walking (Tran et al., 2016) and cycling (Savan, Cohlmeyer, & Ledsham, 2017) groups outside RCs. Moreover, the incorporation of complimentary Fitbit devices provided by the HPB (Yao et al., 2019) with buzz alerts may prompt participants to move more to reduce SB. Taken together, future trials of behavioural strategies to increase walking and cycling PA levels and reduce prolonged sitting time are deserving of attention to curb metabolic risk factors of NCDs.

Besides PA levels, healthy dietary patterns are also associated with an improvement in metabolic risk factors of NCDs among Singaporean women. Significant improvements in the intake of fruit, vegetables, wholegrains, salt and sugar were displayed in the intervention group compared to the control group. These improved eating patterns suggest that the SPANS encourages participants to follow evidence-based dietary guidelines that protect against NCDs (HPB, 2015b; Kimokoti & Millen, 2016). Since dietary intakes were measured by self-report questionnaire, the recall and social desirability bias may restrict the validity of the findings. Future studies can consider validating against objective measures of food intake such as

biochemical markers, provided that the intervention cost and participants' burden of dietary record are reduced via technological devices (Labonte et al., 2016). Future research could consider the usage of cost-effective devices such as mobile phones and tablets to collect data and ease survey burden. Furthermore, the frequency of saturated fat intake remained unchanged. This observation was reflected in the National Nutrition Survey 2018, which showed a slight decrease in saturated fat intake (38% to 36%) among Singaporean adults (HPB, 2018). This is not surprising because 87% of the participants ate out >3 times weekly throughout the SPANS and Naidoo et al. (2017) reported that Singaporean women viewed the convenience, variety and low cost of meals as attractive reasons for their unhealthy eating out practices despite knowing that such meals are cooked in saturated fats like palm oil. Given that saturated fat intake increases the risk of CVD (Scientific Advisory on Nutrition, 2019), it is prudent for the HPB to develop innovative strategies to make healthy eating more accessible and affordable. For example, HPB may subsidise the cost of food products with healthier choice symbols or train chefs in healthier cooking practices across eateries. Furthermore, such initiatives may occur in tandem with the 'Eat, Drink and Shop Healthy Challenge' campaign in future studies to influence dietary changes among older adults.

5.1.5 Objective 5

Objective 5 assessed changes in BP, anthropometric measurements, fasting blood glucose (BG) and lipid profiles and health-related quality of life indicators (HR-QOL) of the intervention group participants relative to the control group participants from pre- to post-test (see **Publication 4**, Appendix B). The significant improvements in systolic BP, diastolic BP and body fat percentage for the intervention group of the SPANS indicate that increased PA and improved dietary behaviours have beneficial effects on health outcomes. It has been long established that metabolic risk factors of NCDs can be improved with combined PA and dietary interventions for older adults (Appuhamy et al., 2014; Baillot et al., 2015; Chapman et al., 2013; Zhang et al., 2017). Considering the rising prevalence of metabolic risk factors such as high BP, obesity and abdominal fatness among Singaporean older women (MOH, 2011a), these findings highlight the SPANS as a potential primary prevention intervention to empower the target group towards the attainment of positive PA and dietary behaviours and health outcomes.

Significant within-group improvements were observed for waist circumference, hip circumference, waist-hip ratio, weight and body mass index only for the intervention group from baseline to post-test. These results are consistent with other PA and nutrition research of ≥6 months duration that displayed improvements in such anthropometric outcomes (Appuhamy et al., 2014; Baillot et al., 2015; Chapman et al., 2013). However, the regression analyses displayed no statistically significant anthropometric changes in the intervention group relative to the control group. The absence of significant findings unlike other PA and dietary interventions may be due to the influence of the 'Hawthorne effect' among intervention and control group participants. However, such an effect is expected to be minimal due to the blinding of the participants throughout the study.

As for blood parameters, the reduction of sugary beverages in both groups could have resulted in a significant decrease in fasting BG levels found within and between both groups pre- and post-test. However, no significant improvements were also displayed for the fasting lipid profile within-groups or between-groups. This observation is not surprising because there was no significant change in saturated fat intake, which is strongly linked to a reduction in blood lipid levels in PA and nutrition studies (Scientific Advisory on Nutrition, 2019). The regression analyses revealed no improvement in the lipid and fasting BG profiles after controlling for confounders, which may be attributed to the insufficient duration, frequency and intensity of the aerobic and muscle-strengthening classes. For instance, the six-month SPANS's PA classes lasted only 45 minutes, was conducted twice per month and some classes were tailored to low PA intensity to match participants' physical ability (Wong, Lee, et al., 2020). PA and dietary studies that showed improvements in fasting BG and lipid profiles included longer intervention period (>12 months), longer session duration (≥60 minutes), higher frequency (three times per week) and greater PA intensity (moderate-high) (Bird & Hawley, 2017; Zhang et al., 2017). Similarly, a systematic review of behavioural PA and dietary RCTs conferred significant improvements in fasting BG and lipid profiles when displayed in interventions of higher intensity, greater contact time and longer duration of motivational support by program ambassadors (Greaves et al., 2011; Patnode et al., 2017). Therefore, future PA and dietary interventions should investigate the most

appropriate combination of intervention components to effectively modify the health outcomes of high-risk groups.

Similarly, the regression analyses revealed no significant differences in all the HR-QOL indicators except for ‘no bodily pain’ between the two groups from pre- to post-intervention. As reported in a comparable PA and dietary intervention among community dwelling older Japanese women, a lack of changes in HR-QOL indicators may be due to the participation of health-conscious and motivated volunteers with high self-efficacy, implying minimal social and emotional difficulties (Uritani et al., 2013). Such characteristics of these Japanese women may be prevalent in the SPANS participants who perceived their self-reported health to be good that would explain the non-significant changes in most of the HR-QOL indicators. However, such selection bias has been minimised by the use of a RCT study design in the SPANS.

In summary, these findings demonstrate the effectiveness of the six-month community-based SPANS to improve PA and dietary behaviours, BP and body fat percentage of Singaporean women aged ≥50 years old attending RCs. Given the high prevalence of behavioural and metabolic NCD risk factors among these women, future refinement and upscaling of the SPANS is urgently needed to tackle the escalating chronic disease rates among this priority group. Future PA and dietary interventions should gather multi-sectoral support from the government, practitioners and community organisations to alleviate NCD rates among the target group.

5.2 Study strengths

The SPANS is a first-of-its-kind RCT to be conducted in Singapore RCs targeting women aged ≥50 years old to improve behavioural and metabolic risk factors of NCDs. The study provides a baseline blueprint for the development, implementation and evaluation of a community prevention program in Singapore to curb the rising NCD burden and associated costs. Other strengths of the study are highlighted in this section.

- ***Sound methodology*—**The SPANS used a cluster RCT design that accounted for potential confounders to reduce study bias. Moreover, the investigation of primary and secondary outcome measures allowed the assessment of behavioural and metabolic risk factors to support the effectiveness of the SPANS intervention over time. Furthermore, the study's sample size (n = 580) was of adequate power with a high retention rate (85%) comparable to other Asian interventions (Tran, James, et al., 2017; Yoo et al., 2012), thus increasing the study's validity. PA levels were also objectively measured using accelerometers combined with self-report questionnaires to improve the accuracy of the findings.

- ***Use of theory and model*—**Both SCT and the SEM provided useful frameworks to design behavioural change interventions that target and promote long-term maintenance of positive PA and dietary practices (Golden & Earp, 2012; Stacey et al., 2015). These frameworks account for the personal and socio-environmental determinants to guide the development of the SPANS strategies and enhanced participants' autonomy towards health modifications.

- ***Techniques to change behaviour*—**Various BCTs such as goal-setting, self-monitoring, feedback and problem solving, including MI techniques promoted self-efficacy among participants (Samdal et al., 2017). Since behaviour changes are challenging, the combination of BCTs and MI techniques were complementary strategies used to motivate and sustain PA and dietary practices.

- ***Comprehensive process evaluation*—**Process evaluation is often neglected but is essential to examine implementation components such as recruitment, compliance and satisfaction to achieve program fidelity and internal validity (Wong, Lee, et al., 2020). Based on a comprehensive process evaluation framework (Saunders et al., 2005), the SPANS identified intervention components that improved the study's effectiveness to guide future research.

- ***Supporting audit study*—**The audit of RCs' facilities and activities examined the built and social environment to support participants' behavioural changes (Wong et al., 2019). It facilitates the understanding of barriers, motivators and preferences of the target group utilising the RCs. The study informs improvements in future programs aimed at fostering positive behavioural changes and consequently improve health outcomes.

5.3 Study limitations

The study limitations of the SPANS are discussed in this section. It is plausible that such limitations influenced the study's findings.

- ***Social and economic aspects of the intervention*—** Complex social and economic analyses were beyond the scope and resources of the SPANS.

- ***Characteristics of the target group*—**Singaporean females of Chinese descent aged ≥50 years old formed the target group because they make up the predominant users of RCs (82% of the patrons) (Wong et al., 2019). In contrast, only a small percentage of Malays and Indian women aged ≥50 years old (5%) participated in the study. Since there was a possibility of recruiting healthy and motivated participants, there was a likelihood of selection bias in the sample group. Moreover, the results cannot be generalised to other adult populations, including adults facing inequalities in risk factors of NCDs (e.g., existing chronic conditions, disabilities, low educational and socio-economic status), males or younger adults. The percentage of older women (>63 years old) was higher in the intervention group (58%) compared to the control group (45%), which may have affected the results. To ensure a more homogenous study group in future studies, the recruitment age should be restricted to participants <70 years old.

- ***Measurement instruments*—**Self-reported PA and dietary practices may introduce poor recall and social desirability bias (Sternfeld & Goldman-Rosas, 2012). The program ambassadors who conducted the face-to-face measurements were not blinded to the group allocation of the participants. However, participants were blinded to their group allocation, reducing any differential in

over- or under-reporting of behaviours and any inaccuracies would be expected to be similar across intervention and control groups. As the information collected from the questionnaires and exit interviews were written in either English or Chinese, inaccuracy in the translation process may have compromised the data quality as reported in an earlier Singaporean PA study (Léonie et al., 2019). However, it was necessary to use the Chinese language because of the high percentage of Mandarin-speaking participants. Although accelerometers were used objectively to measure PA levels, the convenience sub-sample of intervention participants who agreed to wear the devices may have been a more motivated population. However, Goode et al. (2017) pointed out that such motivating effects and the novelty of such devices plausibly wear off over time. Hence, it would be prudent for future interventions to consider providing accelerometers to both intervention and control group participants to further validate the study's findings.

- ***Intervention duration*****—**The sustainability and effectiveness of PA and nutrition interventions remain challenging due to a lack of time and funding in Asian studies (Soon et al., 2013; Tan et al., 2011; Tran, James, et al., 2017). Limited resources and budgetary constraints restricted the SPANS intervention to 6 months. Since this brief period cannot confirm the sustainability of outcomes, a longer follow-up assessment should be implemented to assess the effectiveness of the SPANS over time.

- ***Confounding effects and bias***—Although the SPANS controlled for confounders in the regression analysis, residual confounding may still affect the results (Tran, Lee, et al., 2017). Moreover, performance and selection bias may influence the findings. These biases may have resulted from not blinding the program ambassadors and the principal investigator to the study and cross-contamination across intervention and control RCs due to Singapore's small population area of only 719 km² (SDOS, 2019).

Chapter 6
Conclusions and Recommendations

The development, implementation and evaluation of the Singapore Physical Activity and Nutrition Study (SPANS) was a timely and culturally appropriate community-based intervention aimed at increasing our understanding of the impact of community-based physical activity (PA) and nutrition randomised controlled trial (RCT) within the context of Singapore. The findings showed improvements in PA and nutrition behaviours and some metabolic risk factors of non-communicable diseases (NCD) in Singaporean women aged ≥50 years old (Wong, James, Lee, & Jancey, 2020). The intervention group showed significant improvements in PA (moderate-intensity, vigorous-intensity and total), increased intake frequency of fruit and vegetables and reduction in salt and sugary beverages as well as reductions in systolic and diastolic blood pressure and percentage body fat when compared to the control group. Although the SPANS achieved sound outcomes, sitting time, anthropometry (weight, body mass index, waist-hip ratio, waist circumference and hip circumference), fasting blood glucose and lipid profile remained unchanged over the 6-month intervention period.

These outcomes may have been impacted by the limited resources and budgetary constraints, as the SPANS was only able to be conducted over a period of six months. Long-term cost-effectiveness analyses of such PA and dietary programs are needed. A longer follow-up with a booster intervention of >12 months (after the six-month intervention) is recommended to confirm intervention effectiveness. However, longer-term interventions will require prioritising NCD prevention and significant commitment and continual investment by the government.

Future interventions should consider policy and or organisational approaches guided by the Socio-Ecological Model (SEM) to inform future iterations of the SPAN's like interventions. For instance, NCD prevention programs could involve partnerships with government organisations, such as the Sports Singapore and the Health Promotion Board. These organisations have the capacity to fund initiatives. This funding could include the training of RC managers and the provision of educational resources and Fitbits. In addition, government policies to support the auditing and upgrading of RCs'

facilities and activities, could actively engage the ageing communities. In the short term, a *policy brief* (see **Appendix Y**, *Effectiveness of SPANS Intervention*) could be used to lobby the government to build well-equipped RCs with more subsidised activities on offer. In the longer term, government organisations could collaborate to replicate the SPANS in RCs, which are ageing-in-place settings.

Improved behavioural change and health outcomes require active partnerships and collaboration between academics, health practitioners and policymakers. Significant behavioural changes and accompanying health outcomes often require a team of experts and a longer study period for monitoring of PA and dietary behaviours and intervention outcomes, particularly in the high-risk target groups. For example, complex behaviour change such as sedentary behaviour may require the skills of a transdisciplinary team of psychologists, public health practitioners, economists and data scientists, together with nutritionists and exercise specialists to analyse trends in sitting patterns. The collaboration between such stakeholders may support the development of innovative and pragmatic PA and nutrition intervention programs that are beneficial for inactive groups, such as older adults.

There is also a need for capacity-building among researchers and practitioners to equip them with the skills to better target and support behaviour changes for at risk ageing populations. Such collaborations among health professionals could explore whether the intervention model tested, and the process and impact findings may be used to inform strategies in other research areas e.g., reducing inequities in risk factors of NCDs for the target group. Research implemented by multiple stakeholders has the potential to better support the amelioration of the chronic disease burden and associated costs.

The popularity of RCs made them an appropriate venue for recruiting Singaporean women aged ≥50 years old, while their accessibility made them ideal for implementing behavioural change interventions with this older target group (Wong et al., 2019). Investment in these centres will increase their attractiveness and relevance to the target group and increase the value of RCs as a hub for community activities and socialising.

A synergistic partnership between RC managers and participants in revamping RCs' facilities and activities is important in facilitating older adults' PA and dietary behaviours. Given the supporting role of RC managers in the SPANS, an *infographics poster* (see **Appendix Z**, *Get Active, Stay Healthy at RCs!)* will be disseminated to all RC managers to inform them of the effective outcomes of the SPANS, with the intent of rallying support for the replication of the SPANS intervention in other RCs. Active engagement and periodic consultation between the participants and RC managers are imperative to ensure that the socio-environment of the health-promoting RCs stays relevant to the needs, lifestyles and interests of participants to facilitate positive PA and dietary practices. In turn, this reciprocal exchange of knowledge between the participants and RC managers in designing culturally appropriate PA and dietary opportunities may increase their ownership of the program and inform RC policy and practice for chronic disease prevention.

Overall, the SPANS RCT contributed to the knowledge base of PA and dietary behavioural interventions, specifically targeting Singaporean women aged ≥50 years old who attend RCs. Findings from the SPANS are consistent with other community-based interventions in demonstrating that PA and dietary behavioural change interventions are useful for empowering older adults to adopt long-term PA and dietary changes within supportive RC environments. The positive PA and dietary behaviours, along with accompanying reduction in some metabolic risk factors in the SPANS, offer a potential blueprint for future behavioural interventions among older Singaporean women. Active collaboration between participants and the RC managers including support from the government, researchers and health practitioners is urgently needed in health promotion efforts and disease prevention initiatives. Broadening the scope of future interventions by refining the SPANS to include a range of social-environmental, economic and policy issues that sit within a SEM framework could improve primary efforts in NCD prevention among the at risk target group. Gaining the government's support for such interventions remains an urgent priority for NCD prevention in Singapore.

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APPENDICES

APPENDIX A: STATEMENT OF CONTRIBUTION OF OTHERS

Curtin University

18th December 2020

To Whom It May Concern

I, Jonine Jancey, contributed as a supervisor of the PhD candidate. I had ongoing and close involvement with the research study, provision of close supervision of the candidate in research proposal, study design and methodology, revised manuscripts and suggested improvements for the following publications:

1. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: study protocol for a randomised controlled trial. *Trials*, 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

2. **Wong, E. Y.-S**., Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore. International Journal of Environmental Research and Public Health, 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343

3. **Wong, E.Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process Evaluation of the Singapore Physical Activity and Nutrition Study. *Evaluation and Program Planning*, 83, 101847. http://doi:https://doi.org/10.1016/j.evalprogplan.2020.101847

4. **Wong, E.Y.-S.,** James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: a cluster randomised controlled trial. *Asian Pacific Journal of Public Health.* https://doi.org/10.1177/1010539520977311

Curtin University

18th December 2020

To Whom It May Concern

I, Dr Anthony P James, contributed as a co-supervisor of the PhD candidate. I had ongoing and close involvement with the research study, provision of close supervision of the candidate in research proposal, study design and methodology, revised manuscripts and suggested improvements for the following publications:

1. **Wong, E. Y.-S**., Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: study protocol for a randomised controlled trial. *Trials*, 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

2. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore. International Journal of Environmental Research and Public Health, 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343

3. **Wong, E.Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process Evaluation of the Singapore Physical Activity and Nutrition Study. *Evaluation and Program Planning*, 83, 101847. http://doi:https://doi.org/10.1016/j.evalprogplan.2020.101847

4. **Wong, E.Y.-S.,** James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: a cluster randomised controlled trial. *Asian Pacific Journal of Public Health.* https://doi.org/10.1177/1010539520977311

Curtin University

18th December 2020

To Whom It May Concern

I, Professor Andy Lee, contributed as a co-supervisor of the PhD candidate. I had ongoing and close involvement with the research study, provision of close supervision of the candidate in research proposal, study design and methodology, revised manuscripts and suggested improvements for the following publications:

1. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: study protocol for a randomised controlled trial. *Trials*, 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

2. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore. International Journal of Environmental Research and Public Health, 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343

3. **Wong, E.Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process Evaluation of the Singapore Physical Activity and Nutrition Study. *Evaluation and Program Planning*, 101847. http://doi:https://doi.org/10.1016/j.evalprogplan.2020.101847

4. **Wong, E.Y.-S.,** James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: a cluster randomised controlled trial. *Asian Pacific Journal of Public Health.* https://doi.org/10.1177/1010539520977311

APPENDIX B: LIST OF PUBLICATIONS

APPENDIX B - Publication 1

Wong *et al. Trials* (2018) 19:257
https://doi.org/10.1186/s13063-018-2562-2

Trials

STUDY PROTOCOL Open Access

Physical activity and nutrition intervention for Singaporean women aged 50 years and above: study protocol for a randomised controlled trial

Elaine Yee-Sing Wong[1*], Andy H. Lee[1†], Anthony P. James[1†] and Jonine Jancey[2†]

Abstract

Background: The majority of the older Singaporean women aged 50 years and above are physically inactive and have unhealthy dietary habits, placing them at 'high risk' of non-communicable diseases (NCDs). The adoption of regular physical activity (PA) and a healthy diet are essential lifestyle behaviours to reduce this risk. This randomised controlled trial (RCT) involves the development, implementation and evaluation of a PA and nutrition programme for community-dwelling Singaporean women who currently attend recreational centres (RCs are public facilities supporting social leisure activities) in their local area. The intervention will be developed after conducting formative evaluation with RC attendees and managers through focus group discussions and pilot testing of resources (i.e. surveys, accelerometers, and health booklets). Programme ambassadors (trained, certified fitness instructors and nutritionists) will deliver all sessions in English and Mandarin; implement classes to meet participants' varying needs; and conduct sessions at different times at convenient venues. Social Cognitive Theory (SCT) has been selected as the theoretical framework to inform intervention strategies as it explores the interactions of human behaviour with the environment and has been found to be valuable when developing behavioural change interventions particularly in older adults (J Gerontol B Psychol Sci Soc Sci 67B(1):18–26, 2012; Obesity Reviews 15(12):983–95, 2014). Its major construct, self-efficacy, is invaluable in achieving successful behaviour change, such as increasing levels of PA or improving dietary intake (Trials. 2017; https://doi.org/10.1186/s13063-016-1771-9; Psychol Health Med 18(6):714–24, 2013).

Methods: The development and implementation of the PA and nutrition intervention strategies will be guided by SCT and Motivational interviewing (MI) and implemented by trained programme ambassadors at the RCs. Sixty RCs located in Singapore will be selected from five major geographical districts and randomly allocated to the intervention ($n = 30$) or control ($n = 30$) cluster. A sample of 600 (intervention $n = 300$; control $n = 300$) women aged 50 years and above will then be recruited from these 60 centres and only the intervention group will be enrolled into the PA and nutrition intervention. It is hypothesised that by the end of the intervention, the intervention group participants compared to the control group will show significantly greater improvements in the following outcome variables: PA and dietary behaviours, health-related quality of life, objective measures of PA, anthropometric, lipid and glucose profiles. Data will be collected at baseline and 6 months and analysed using mixed regression models.

Discussion: It is anticipated that recruitment, retention and compliance of participants will be challenging due to the target group being unfamiliar with such community-based research programmes.

(Continued on next page)

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(Continued from previous page)

Trial registration: Australian and New Zealand Clinical Trials Registry, ACTRN12617001022358. Registered on 14 July 2017. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=372984&isReview=true

Keywords: Community - based, Healthy ageing, Intervention, Nutrition, Older women, Physical activity, Randomised controlled trial,

Background

Singapore is a densely populated city with 5.6 million residents, comprising an ethnically diverse population of Chinese (74%), Malay (13%) and Indians (9%) [1], of which the proportion of dependent older adults is growing, representing a challenge for the health sector [2]. Compared to men, Singaporean women have a longer life expectancy [3]. They also have an increased risk of non-communicable diseases (NCDs), especially for those women aged 45 years and above [4]. Older women have been identified as a priority group to target in reducing the risk factors for all NCDs as the prevalence of high blood pressure (BP), cholesterol and diabetes (type 2) rise sharply for women from their 30s into their 60s [5]. In addition, compared to men, women living in Singapore aged 50 to 69 years have higher levels of abdominal fat (54% versus 9% in men), obesity (11% versus 8% in men), and lower levels of desirable high-density lipoprotein-cholesterol (HDL-C), which is protective against atherosclerosis (5% versus 10% in men) [6]. Unhealthy lifestyle practices among these women, such as the high consumption of readily available low-nutrient, energy dense meals and physical inactivity [6, 7], contribute to their high rates of NCDs.

Adequate levels of physical activity (PA) and a nutritious diet have been recognised as crucial lifestyle factors for the prevention of NCDs [8]. However, based on the National Health Survey, Singaporean women aged over 50 years reported: (1) high levels of leisure time physical inactivity (72%), (2) low levels of regular exercise (16%) and (3) do not meet the recommended levels of PA for health benefit (39%) [6]. Reasons for low levels of participation include: a lack of time due to work and child commitments (47%); perception of doing adequate PA from undertaking housework (23%); and a lack of interest (16%) [6]. Results from the 2010 Singaporean National Nutrition Survey also revealed that a high proportion of Singaporean women aged 50–69 years have macronutrients intake exceeding the Recommended Dietary Allowance (RDA) for energy (58%), total fat (57%), saturated fat (67%), carbohydrate (54%) and protein (71%); but only 62% of them met the RDA for dietary fibre intake [7]. In addition, a lower percentage of these women met the recommended serving guidelines for vegetables (26%), fruits (34%), wholegrains (43%) and fare only slightly better for rice and alternatives (50%) as well as the meat and alternatives food groups (51%) [7].

Most Singaporeans (> 80%), including older adults, reside with their families in dense, affordable public housing [9]. Recreational centers (RCs) are built within this public housing to provide a venue for residents to come together with the intention of fostering community cohesiveness [10]. These RCs are in close proximity and easily accessed, providing an ideal setting to reach the target group and implement and evaluate a community-based PA and nutrition intervention for older women.

Despite the evidence that healthy lifestyle behaviours are linked to a reduction in NCDs [11], limited community-based intervention research has been undertaken in the over-50s target group in Asian communities [12]. The findings reported in the academic literature on the effectiveness of the PA and nutrition strategies in community-based interventions typically originate from Canada, US, Europe and Australia. For example, a systematic review of 17 community-based interventions indicated that PA and nutrition interventions incorporating face-to-face counselling and group session modes of delivery were most effective in a community-based setting [13]. Another review of nine randomised controlled trials (RCTs) reported that nutrition counselling involving active participation in health planning, goal setting, self-efficacy and collaboration were effective in influencing positive nutrition outcomes for older adults [14], while face-to-face meetings were found to be effective [15] due to the relationships that form during the exchange of information [16]. Significant improvement in dietary behaviour and PA levels has been observed in recent health interventions targeting older healthy adults in Asia using Social Cognitive Theory (SCT) [17-19]. Furthermore, a systematic review of SCT in interventions confirmed that it provided a practical and adequate theoretical framework for guiding early phases of intervention development for chronic health conditions [20]. Therefore, the proposed cluster RCT of SCT-based PA and nutrition intervention aims to develop and implement a culturally appropriate intervention to reduce the risk factors associated with NCDs for women aged 50 years and above who utilise RCs. It is hypothesised that levels of PA and dietary behaviours, lipid profiles and fasting blood glucose (BG) levels, as well as anthropometric

measures, will demonstrate statistically significant improvements in the intervention group, when compared with the control group after the 6-month intervention.

Methods

Study design

A 6-month, community-based PA and nutrition cluster RCT suited to the Singaporean context will be implemented and evaluated over two time points (baseline and 6 months); see Table 1. A proposed schedule for enrolment, intervention and assessment is shown in the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Figure (Fig. 1) and recommended items to address for intervention trials are reflected in the Additional file 1: SPIRIT Checklist [21]. A flow chart of the research procedure is displayed in Fig. 2.

Study procedure

Recruitment of RCs

Singapore is divided into five geographical districts, as seen in Additional file 2 [22, 23], which are all similar in terms of socioeconomic status [24]. To enhance the chance of recruiting participants into the intervention programme, three out of the five districts were randomly allocated to the intervention cluster (by drawing names from a bag) and the remaining two districts to the control cluster. The process resulted in the intervention sites (districts: 2-North West, 3-Central, and 5-South East) and control sites (districts: 1-South West, and 4-North East). Sixty RCs (intervention $n = 30$, control $n = 30$) will be randomly selected from these geographical districts. Due to the differences in the number of RCs within the districts, approximately 9–12% of the listed RCs in each district will be chosen using computer-generated random numbers. These RCs will have a minimum separation distance of 4 km to avoid risk of contamination between intervention and control groups. The recruitment process will continue until 30 control and 30 intervention RCs consent to take part in the study. The participants will all be blinded to their group status (intervention and control) during the recruitment and intervention period.

Recruitment of participants

A sample of 600 (interventions $n = 300$; controls $n = 300$) women will then be recruited from these 60 RCs. Participants are required to be: (1) female, aged 50 years and above, (2) undertaking less than 150 min of moderate intensity leisure PA per week (self-reported), (3) not have any medical condition that prohibits involvement in a PA programme, and (4) not currently enrolled in other nutrition and PA research studies.

Table 1 Proposed pre-post data collection and intervention

Study group	(Baseline) 0 month	Intervention	(Post intervention) 6 months
Controls ($n = 300$)	O1		O2
Interventions ($n = 300$)	O1	X	O2

O observation, *X* intervention

Procedure

Programme recruitment flyers will be placed on the RC's bulletin boards and promoted by the RC managers. Those residents indicating to the RC managers that they are interested in the programme and agreeing to provide their contact details will have their telephone number provided to the research team. These participants will then be telephoned to explain the purpose of the study and to determine their eligibility based on the selection criteria. After the initial telephone screening, eligible participants will be invited to take part, informed of their rights and confidentiality issues, and that they are free to withdraw at any stage.

At the initial meeting, baseline data will be collected and recorded using the health surveys available in the English and Chinese language reflected in the Additional files 3 and 4 [25-27]. Trained researchers (final-year tertiary students) will collect self-reported data on dietary habits and PA levels used to assess current dietary and PA levels and undertake anthropometric measures. These programme ambassadors are final-year nutrition, sports and wellness undergraduate students who will conduct their activities under close supervision of qualified nutritionists and certified fitness instructors. The principal investigator (PI) will fit and explain the management of the accelerometers. Fasting blood samples will be collected by a phlebotomist. Any participants exhibiting hypercholesterolaemia (total cholesterol (TC) ≥ 6.2 mmol/L) [28] or hyperglycaemia (BG > 7 mmol/L) levels [29] will be excluded from the study and referred to their medical practitioner for follow-up. Participants on medication will not be excluded and both the pre and post survey will document all those who are on medication including the type of medication and subgroup analysis will be undertaken.

Both the intervention and control participants who undergo pre and post data collection will be given an incentive of free health products (health calendar, sports towel, writing pad and pen with health messages) and supermarket vouchers in appreciation of their involvement in the study. However, the control group will be blinded to the nature of the intervention and instead only receive a falls prevention booklet.

Sample size determination

The power calculations are based on a logistic mixed regression model with the prevalence of moderate intensity PA participation as the outcome variable. An appropriate sample size for this study is determined in a similar manner to previous studies which examined

	Before the start of intervention	Baseline	Intervention	Post intervention
TIMEPOINT		*0 months*	0-6 months	After 6 months
ENROLMENT:				
Ethics approval	X			
Trial Registration	X			
Pilot testing of resources (survey, accelerometer & booklets)	X			
Recruit & train programme ambassadors	X			
Incentives for participants	X			
Baseline evaluation		X		
Recruitment		X		
Prescreening of participants on eligibility		X		
Informed consent		X		
Process evaluation			X	
INTERVENTION:				
Intervention group			X	
Control group				
ASSESSMENT for intervention and control participants:				
[Primary outcome variables: *Self-reported PA and dietary behaviours; objectively measured levels of PA; lipid profile and BG]*		X		X
[Secondary outcome variables: *anthropometric measurements – weight, height, BMI, waist hip circumference, and body fat percentage; BP and self-reported health related QOL]*		X		X

Fig. 1 Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Figure: proposed schedule for enrolment, intervention and assessment. *BG* blood glucose, *BMI* Body Mass Index, *BP* blood pressure, *PA* physical activity, *QOL* quality of life

effective recruitment and retention of older adults in a PA programme [30]; PA and nutrition intervention for seniors [31]; as well as PA and nutrition intervention targeting middle-aged adults [32]. For the mixed regression analyses when adjusting for the clustering of RCs, a sample size of n = 480 participants (240 participants per group) will allow for an 80% statistical power to detect a medium effect size of 10% improvement in PA prevalence (sufficient leisure time PA estimated to be 28% at baseline) [6] by the intervention group relative to the control group at a significance level of 5%. To account for a 20% attrition rate between the two time points (pre

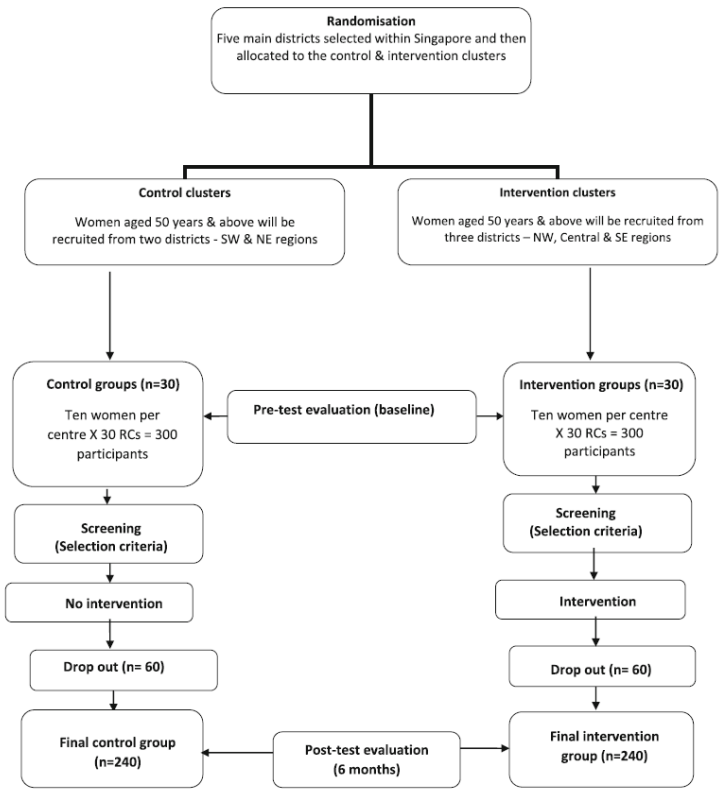

Fig. 2 Flow chart of the research procedure. *NE* North East, *NW* North West, *RC* recreational centre, *SE* South East, *SW* South West

and post intervention), a total of n = 600 adult women will be initially recruited at baseline. The sample size takes non-respondents into consideration within the duration of the study but without covariate adjustment.

Outcome measures

Table 2 summarises the outcome variables and how they relate to their corresponding measurement tools.

Primary outcome variables

Self-reported PA behaviour will be obtained through the administration of the Global Physical Activity Questionnaire (GPAQ), a widely used instrument specifically developed by the World Health Organisation (WHO) for population-wide PA surveillance, and is available in the Chinese language [33]. This instrument has acceptable measurement properties and was used in the National Health Survey to collect data on Singaporeans aged 18–69 years on PA levels [6]. In Singapore, this tool has demonstrated fair-to-moderate correlations for moderate-to-vigorous PA for validity and moderate levels of reliability [34].

Accelerometers (ActiGraph GT3X) [35] will be explained and fitted to the intervention participants. They will wear this device on their right hip for seven consecutive days at baseline and 6 months (post intervention) and remove it when sleeping, showering or doing water-based activities. Data collected will be downloaded using the ActiLife 6 software. This information will be summarised into daily average counts (counts per min) and duration of activity (min per day) at specific intensity levels (inactive, light, moderate, and vigorous) [36].

Self-reported dietary eating habits will be assessed through a WHO-developed, standardized STEPS dietary behaviour questionnaire to monitor the main NCD risk factors [37]. This is a feasible, low-cost nutrition

Table 2 Primary and secondary outcome variables and measuring tools

Primary outcome variables	Measurement tools
Self-reported levels of PA behaviour (incidental, programmed and sedentary)	GPAQ
Objectively measured levels of PA: intensity, duration and frequency	ActiGraph GT3X accelerometers
Self-reported levels of dietary behaviours on wholegrains, fat, oils, salt, sugar, fruits and vegetables consumption	STEPS dietary behaviour questionnaire
Lipid profile – cholesterol and TG, BG	Fasting blood samples
Secondary outcome variables	**Measurement tools**
Anthropometric measurements – weight, height, BMI, waist hip circumference and body fat percentage	Portable stadiometer, calibrated weighing machines, tape measures and Endo Body Fat Composition Analyser E-DBS908
BP	Omron electronic BP monitor
Self-reported health-related QOL	SF-8 questionnaire

BG blood glucose, *BMI* Body Mass Index, *BP* blood pressure, *GPAQ* Global Physical Activity Questionnaire, *PA* physical activity, *QOL* quality of life, *SF* Short Form, *TG* triglyceride

assessment tool comprising 21 questions measuring dietary consumption of wholegrains, fat, oils, salt, sugar, fruits and vegetables for the past week [26].

Blood samples

A fasting (> 10 h) blood sample will be collected from the antecubital vein of all participants by trained phlebotomists into appropriate vacuum tubes [38]. All blood analysis will be carried out at the Quest Lab pathology laboratory using an Abbott Architect autoanalyser according to the manufacturer's instructions. The assays for TC, triglyceride (TG) and glucose are all based on standard enzymatic colourimetric methodology [39, 40]. Serum low-density lipoprotein-cholesterol (LDL-C) will be calculated by the modified Friedewald equation and non-HDL-C will be calculated by subtracting the HDL-C from the TC [41, 42].

Secondary outcome variables

Weight will be measured (wearing light clothing without shoes) using a calibrated electronic scale and recorded to the nearest 0.01 kg while *height* will be measured with a portable stadiometer to the nearest 0.1 cm (barefooted) [43, 44].

Body Mass Index (kg/m^2) will be calculated as weight in kilograms divided by the square of height in metres [45].

Body fat percentage will be measured by an Endo Body Fat Composition Analyser E-DBS908 (without shoes and socks) [46].

Waist circumference will be measured by a non-stretch tape, standing up at the level midway between the lowest rib margin and the iliac crest and recorded to the nearest 0.1 cm [47].

Hip circumference will be measured at the widest circumference at the level of the symphysis pubis and gluteus maximus [32].

Waist hip ratio will be calculated as waist circumference divided by hip circumference [48].

Systolic and diastolic BP will be taken from the left arm after consecutive measurements of the participants seated down and rested with an appropriate-sized cuff placed at the heart level using an Omron electronic BP monitor [49, 50].

Self-reported health-related quality of life (QOL) using the Short Form (SF)-8 questionnaire will assess the health-related QOL and provide a brief overview of the physical, psychological and social domains of health to further support the study [51, 52].

Demographic data including age, ethnicity, education, marital status, existing medical conditions, type of medications use and type of housing dwelling will be collected.

Process evaluation

This will be undertaken throughout the intervention programme to determine reach (attendance); fidelity (quality of programme, programme delivery and resources), together with recruitment, dose delivered and received [53]. Criteria for assessing programme quality will take into account: (1) utility: information needs of participants are satisfied, e.g. usefulness of resources; (2) feasibility: cost-effectiveness, e.g. efficiency of evaluation process

to justify use of available resources; (3) propriety: ethical standards are met, e.g. aggregated evaluation findings are made accessible to participants; and (4) accuracy: valid and reliable information, e.g. clear and accurate report documentation [54]. Structured feedback forms and focus group interviews will be undertaken with the participants to determine the effectiveness of programme and programme ambassadors; explore barriers, motivators; and satisfaction levels [55]. Collection of these data will provide information on the effectiveness of strategies, applicability of resources, and other factors that impact upon the delivery of the intervention [56]. These pertinent details will provide insight into programme implementation and factors that influence participation.

Exit interviews will be undertaken with programme completers (n = 12) and non-completers (n = 12). This sample size is considered adequate for non-probabilistic purposeful sampling [57]. Informed verbal consent will be obtained prior to conducting the interviews. The interviews will explore perception of the resources, the intervention and the programme ambassadors. Reasons for programme withdrawal will be obtained from non-completers. It is estimated that the face-to-face exit interviews will be of 20-min duration.

Theoretical framework

Theoretical perspective underpinning this study is the SCT, which identifies the interaction of the individual with the social and physical environment, and how this interaction influences health behaviours in older adults [58-60]. It specifies a set of psychosocial constructs that include self-efficacy; outcome expectations (cognitive influences); observational learning and social support (environmental influences); as well as goal-setting and reinforcement (behavioural influences) which are described in Table 3 [61, 62]. In addition, Motivational Interviewing (MI) techniques will be used during the intervention delivered by the programme ambassadors. This is a person-centred, collaborative communication style, to raise commitment and reinforce behaviour change [63]. Studies on applied MI strategies have demonstrated its practicality in positively tackling unhealthy dietary and low PA levels [64, 65]. The use of these techniques in this study will support autonomy and heighten intrinsic motivation towards healthier lifestyles.

Intervention

This 6-month community-based Singapore Physical Activity and Nutrition Study (SPANS) intervention programme will be based on the Singaporean PA and nutrition guidelines [66-68]. Programme ambassadors will undergo comprehensive training in MI and intervention programme and will undertake all the intervention activities and distribute the resources bi-weekly (see Table 4).

Group PA, nutrition talks, dietary counselling sessions and telephone contact

Bi-weekly, low-intensity PA, strength and balanced exercises sessions will be conducted. There will be bimonthly nutrition talks, bimonthly dietary counselling and monthly follow-up calls incorporating MI. Programme ambassadors will follow-up with participants' enquires and provide feedback to support the adoption of healthy practices and monitor the progress of their participants' goals. Participants will be encouraged to do moderate intensity PA for at least 150 min per week and reminded to monitor their daily progress and goals by recording the frequency and duration of PA in a health calendar provided at the commencement of the programme. Goal setting and feedback will be emphasized at all contact points during the intervention.

Educational resources

The programme ambassadors will introduce the 6-month intervention; distribute the resources throughout

Table 3 Application of Social Cognitive Theory (SCT) to inform strategies and methods

SCT	Strategies	Methods
Environment	Build physical and nutrition supports within the RCs	Conduct face-to-face meetings, follow-up calls and provide educational resources
Outcome expectations / Expectancies	Educate on the benefits of nutritious diet and regular PA / achievement of better health screening results and MI	Introduce concept of goal setting and resources at initial meeting; undertake face-to-face sessions, follow-up calls and feedback sessions
Self-efficacy	Goal setting, monitor progress and mastery of health practices and MI	Regular coaching and feedback on participants' PA and nutrition goals towards improving health outcomes (incremental and achievable). Programme ambassadors encourage the adoption of health-enhancing behaviour and practice of new skills and provide feedback
Observational learning	Observe programme ambassadors' dietary and PA behaviours	Demonstrate PA and showcase cooking advice practices. Programme ambassadors act as positive role models
Positive reinforcement	Education and skill building sessions and MI	Regular encouragement, ongoing monitoring of personal PA goals through follow-up support and feedback

MI motivational interviewing, *PA* physical activity, *RC* recreational centre, *SCT* social cognitive theory

Table 4: Singapore Physical Activity and Nutrition Study (SPANS) intervention

Session (timing)	Session details	Participant's resources / interactive activities
PA sessions **(1 hr- twice a month)** **[Week 2 -24]**	1. Introduction to SPANS programme 2. **Focus PA:** aerobic • Benefits/barriers/motivators • Guidelines 3. Establish short and long term PA goals	1. **Resources** • 'Active for Life' booklet 2. **Interactive activities** • PA warm up • Muscle strengthening and low intensity aerobic workout • Cool down and stretches
Nutrition session 1 – Eat Well, Live Well **[Week 1]**	1. **Focus on nutrition** • Benefits/barriers/motivators • Healthy plate model and guidelines 2. Establish short and long term nutrition goals	1. **Resources:** • 'Nutrition Guide for Healthy Aging' booklet • Health calendar with monthly recipes and health tips 2. **Interactive activities:** • What's On Your Plate? • Read your food label
Nutrition session 2 – Smart Shopping and Dining Alert [Week 12]	1. **Focus on nutrition** • Healthy shopping and cooking tips • Healthier Choice Symbols	1. **Resources** • 'Recipes for Health Aging' booklet • 'Lowering BP' booklet 2. **Interactive activities** • Ranking game on food calorie • Guess the herbs and spices in cooking
Nutrition session 3 – Take Charge Of Your Health **[Week 24]**	1. **Focus on nutrition and PA** • Manage cholesterol and BG levels 2. Identify social support and overcome relapse	1. **Resources** • 'Keeping Cholesterol in Check' booklet • 'Tips to Better Health: Keeping My Blood Sugar Levels Healthy' booklet 2. **Interactive activities** • Mix and match cholesterol in foods • Brainstorm on improving BG levels
PA and nutrition counselling **(45 mins – once every 2 months)** **[Week 4, 12, 20]**	1. **Focus on behavioural change** 2. Record dietary and PA record 3. Set, review short and long term goals 4. Provide guidance and support on healthy lifestyle	1. **Resources** • Fridge magnet with reminders on 'Eat More Fruits and Vegetables' • Tote Bag on 'Healthy Living' • Sports towel with 'Warm Up Before PA' slogan 2. **Interactive activity** • Goal setting and reflection
Follow-Up Calls / PA and nutrition text phone messages **(once per month)** **[Week 4 -24]**	1. A monthly PA and nutrition 'tip of the day' will be sent via a "WhatsApp" chat platform.	**Interactive activity** • Participants send other health-related messages to simulate discussion.

the intervention period; and ask participants to use the booklets as a guide to healthy ageing.

Booklets

1. '*Active for Life*': benefits of PA; guidelines for frequency, intensity, time and type of PA; and safety issues
2. '*Recipes for Healthy Ageing*'– *Nutrition Guide and Recipes*: my healthy plate model; dietary guidelines for older adults; tasty recipes; and healthy eating tips
3. '*Lowering BP*' booklet: healthy BP range; problems of high BP levels; dietary sources of sodium; and ways to control and manage BP levels
4. '*Keeping Cholesterol in Check*': dietary sources of cholesterol; ways to reduce dietary cholesterol; and recipe modification for better heart health
5. '*Tips to Better Health – Keeping my Blood Sugar Levels Healthy*': pre-diabetes and diabetes; issues of high BG levels; and how do I control my BG levels?

Calendar

Participants will receive easy, healthy recipes found to enhance the adoption of healthy dietary behaviours among women of lower health literacy levels [69] in a *'health calendar'* that contains health tips acting as reminders to stay active and eat healthily.

(These resources are available from the first author upon request).

Health text messaging

A nutrition and PA 'tip of the month' will be sent to all participants as text messages via "WhatsApp" on a monthly basis to motivate them to practice healthy lifestyle habits.

Statistical analysis

After data collection, outcome variables of interest, such as blood profiles, self-reported PA and dietary

behaviours, and anthropometric measures will be examined and compared between subgroups of interest via the Statistical Package for the Social Science version 24 [70]. Descriptive and summary statistics will be used to quantify participants' characteristics and outcome variables. Non-parametric statistics will be applied whenever non-normality of the outcomes is detected. Multi-variable mixed regression analyses will be used to confirm the effects of the proposed intervention, taking into account the repeated measures (at two time points) and the clustering of the observations. All variables will be entered using the stepwise regression. The regression model will also account for effects of potential confounders (age, ethnicity, education, marital status, consumption of medication and housing type).

All qualitative data from process evaluation will be transcribed, with at least 10% of all transcribed data randomly selected and reviewed for each transcription. Transcribed data will be coded to create common themes or categories. Data will be collated, presented thematically and supported by direct quotes from participants. Data management of full transcripts and other texts will be facilitated by the NVivo software package [71] to conduct a framework analysis [72, 73]. Participants will not be identified in any transcription.

Discussion

Given the less than optimal dietary habits and low levels of PA among Singaporean women, it is imperative to develop appropriate lifestyle interventions to support the adoption of health-enhancing lifestyle behaviours. RCs provide a community setting to reach this target group to implement a programme that supports an increase in knowledge and development of skills to encourage behaviour change. The proposed study represents the first PA and nutrition cluster RCT located in RCs to be conducted in Singapore with older women. It will give valuable information on PA and nutrition behaviours to enhance healthy ageing outcomes. Moreover, findings from this study may provide insights and recommendations for policy-makers and key stakeholders to develop, modify or create new healthy living RCs with supportive environments in the future.

Trial status

Recruitment of intervention and control group participants, was still ongoing at the time of manuscript submission.

Additional files

Additional file 1: SPIRIT 2013 Checklist: recommended items to address in a clinical trial protocol and related documents. (DOC 127 kb)

Additional file 2: Stratified cluster random sampling of the 5 major districts in Singapore for the physical activity (PA) and nutrition intervention. (DOC 169 kb)

Additional file 3: Health survey: English. (PDF 318 kb)

Additional file 4: Health survey: Mandarin. (PDF 553 kb)

Abbreviations

BG: Blood glucose; BMI: Body Mass Index; BP: Blood pressure; GRC: Group representative constituency; GPAQ: Global Physical Activity Questionnaire; HDL-C: High-density lipoprotein-cholesterol; LDL-C: Low-density lipoprotein-cholesterol; MI: Motivational Interviewing; NCDs: Non-communicable diseases; PA: Physical activity; PI: Principal investigator; QOL: Quality of life; RC: Recreational centre; RCT: Randomised controlled trial; RDA: Recommended Dietary Allowance; SCT: Social Cognitive Theory; SF: Short Form; SMC: Single member constituency; SPANS: Singapore Physical Activity and Nutrition Study; SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials; TC: Total cholesterol; TG: Triglyceride; WHO: World Health Organisation

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Availability of data and materials

Data and intervention materials are available from the first author upon request. Curtin University of Technology will have access to the final trial dataset, and there is no contractual agreements that limit its access for the investigators. Individual information will not be released owing to confidentiality agreements signed by the study participants.

Authors' contributions

EYSW co-ordinated the Singapore Physical Activity and Nutrition study and drafted the manuscript. EYSW, JJ, AHL and TPJ designed the study and revised the manuscript. All authors read and approved the final version for publication.

Ethics approval and consent to participate

The research protocol was approved by the Curtin University Human Research Ethics Committee (approval number: HRE2016–0366). The results of the study will be disseminated through reports, publications and conference presentations. Written informed consent was sought from all participants prior to entry into the study.

Consent for publication

Written informed consent for the publication of these details are obtained from the participants. This consent is for publication of their details under the Creative Commons Attribution License 4.0 (such that they will be freely available on the internet). If the person has died, consent for publication will be obtained from their next of kin.

Competing interests

The authors declare that they have no competing interests.

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APPENDIX B - Publication 2

International Journal of
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MDPI

Article

Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore

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Abstract: Objective: This study examined the physical and social environment (facilities and activities) of Singapore's Recreational Centres (RCs) and female patrons' (>50 years) perception of the RC facilities and activities. Materials and Methods: A total of 100 RCs were audited, and 22 face-to-face interviews were undertaken. Results: Physical activity classes were the main activity offered (mean = eight classes per month), with walking (29.8%) and aerobics sessions (17.5%) being the most frequent. Nutrition classes and social activities were offered less often (mean = one class per month). The activities were well received by patrons, offering opportunities to interact while participating in physical activity and nutrition classes. However, the need for staff training, consideration of patron's abilities and the desire to engage in alternative activities were expressed. Conclusion: Overall, RCs' facilities and activities were well liked by the patrons but opportunities for improvements were identified. Regular reviews of facilities and activities through consultation with the RC patrons and managers are needed to ensure that the facilities and activities remain relevant and practical to the patrons. This will help to support active lifestyles and healthy eating practices among older adults residing within the community.

Keywords: age-friendly; facilities; healthy eating; health behaviour; health promotion; lifestyle; physical activity; recreational centres

1. Introduction

Inadequate levels of physical activity (PA) and poor dietary behaviours are key modifiable risk factors for non-communicable diseases (NCDs) [1]. These risk factors contribute to two in five deaths worldwide and 30% of the global NCD burden [2]. Studies worldwide have demonstrated that community settings, such as Recreational Centres (RCs), are promising environments to support PA and dietary behaviours and enable individuals to adopt and sustain a healthy lifestyle [3–6]. The local environment surrounding the RCs can potentially provide opportunities to support PA (traffic-free and safe walking routes) or inhibit PA (poor lighting and uneven walkways) [7–9]. In addition, the environment can also encourage healthy eating (communal fruit and vegetables garden) or inhibit healthy eating (presence of unhealthy foods in vending machines) [10,11]. Recent systematic reviews have reported that adults are more physically active when living in close proximity to recreational destinations such as health services, food outlets, parks and shops [12–14], while environments with connected streets, good public transport and ease of pedestrian crossing are positively related to increased PA [4,7,12]. Interventions embedded in the community have also been found to increase social opportunities, strengthen social networks among friends and family members that facilitate healthy eating and active urban living practices [15,16].

Despite the strong evidence that the RC environment (physical and social) may support PA and dietary behaviours [3–6,17], limited research has been undertaken in the over-50 group in Asian communities [18]. Most studies reporting on the effectiveness of community-based lifestyle programs originated from Europe, Canada, USA and Australia. Based on the findings from these studies, further research is recommended to explore the influences (social contact, environmental opportunities and program enjoyment) for effective lifestyle programs, highlighting the need for research on Asian communities and especially the unique RC setting in Singapore.

As Singaporeans age, they become increasingly sedentary. Results from the National Health Survey 2010 revealed that the majority (63%) of the 50–69 years old participated in no leisure time PA, while also consuming high amounts of low-nutrient, energy-dense meals [19,20]. A high proportion of older Singaporean adults aged over 50 years had pre-obesity (34%), high levels of abdominal fatness (32%) and impaired glucose tolerance (22%), with higher rates occurring among older women [20]. These behavioural and metabolic risk factors increase their risk of NCDs [21]. Cardiovascular diseases, cancer and diabetes account for 64% of the disease burden in Singapore [22], as one-quarter of adults aged over 65 have at least one NCD [23]. The Singapore government has invested significantly in the management of chronic diseases such as cardiovascular diseases (US $8.2 billion) [24] and diabetes (US $0.7 billion) annually [25].

Considering the high cost of NCD management, the high prevalence of metabolic risk factors and unhealthy lifestyle practices among older Singaporean adults [26], there is an urgency to examine the physical and social environments to develop effective community-based programs to enhance health behaviours. Multi-component strategies in health programs that include group education, PA classes and dietary counselling sessions have resulted in improvements in physiological outcomes [27–29]. Additionally, available evidence indicates that there is some cost-effectiveness in community health programs [30]. Studies undertaken in Western developed countries have reported achieving lower cost per quality adjusted life years (QALYs) through health programs conducted for a longer duration [31]. These programs focused on different NCDs, such as diabetes and cardiovascular diseases, and ranged from US$1413 to US$7301 per QALY gained for adults, depending on the extent, duration and resources of the program [31–35]. Singapore's unique RCs may provide an opportunity to promote cost-effective lifestyle programs to support health-enhancing behaviours.

Singapore's RCs are communal spaces built in the 1970s to support a sense of community among residents who had moved out of their rural village into these urban Housing Development Board estates [36]. These RCs were built below the dense high-rise public housing, where more than 80% of Singaporeans now reside [37]. These public communal spaces serve as a venue for residents to undertake activities, interact and foster community cohesiveness [38]. There are 579 RCs located across the five major districts in Singapore (Central (n = 164), North-East (n = 140), South-West (n = 115), North-West (n = 106) and South-East (n = 54)), each with a similar socioeconomic status [39]. These RCs are staffed with managers who collaborate with the Health Promotion Board (HPB) to promote health and wellness activities [40]. The HPB has been tasked with the vision of building "a nation of healthy people" by encouraging health-enhancing behaviours and preventing illness, disability and premature death [41]. The majority of patrons who frequent these RCs are women aged 50 years and over [42,43], providing a local community environment to support positive changes in PA and dietary behaviours for this 'at-risk' group [44], yet little evidence has been documented [4,45], especially how the RCs can engage and empower these older Singaporean women in healthy lifestyles.

The present study provided the first report to address this gap in the literature. It aimed to examine the physical environment (facilities and activities) of the RCs and female patrons' (>50 years) perception of the RC facilities and activities. The study was underpinned by the social-ecological model and Social Cognitive Theory (SCT) due to the interplay between various health determinants. The model aids in understanding the complexity of health behaviours [46,47], emphasizing the multiple levels of influences (individual, interpersonal, community) that shape health behaviours within the environment [48]. The principles of the model are consistent with SCT concepts, which recognise that

people are not only driven by inner forces or shaped by external influences [49], but also by human behaviour, cognition, personal factors and the environment [50]. Both quantitative (assessment of the physical environment) and qualitative (interviews with RC patrons to assess their experiences) data were collected to identify activities and facilities offered by the RCs, and the patrons' perceptions of these activities and facilities. Such information will assist our understanding of these facilities and their usage, which is important for the development of strategies for cost-effective programs to increase engagement with RCs.

2. Materials and Methods

2.1. Recreational Centre Recruitment

Of the 579 RCs located across the five major Singapore districts (Central, South West, North West, South East and North East), 121 were randomly selected using an online computer random number generator (see Table 1). The RC managers were contacted to explain the purpose and scope of the study. Among them, 100 managers agreed to participate. They were informed of their rights and that the audit would be kept strictly confidential and non-identifiable. A suitable time was then organised for one of the five trained research assistants (qualified nutritionists or certified fitness instructors) to visit the RC, discuss the centre's profile and undertake the audit.

Table 1. Samples of Recreational Centres (RCs) from five Singapore districts.

District	No. of RCs in District	No. of RCs Audited
Central	164	20 (12%)
North East	140	26 (19%)
South West	115	24 (21%)
North West	106	17 (16%)
South East	54	13 (24%)
TOTAL	579	100 (17%)

The standardised training of the research assistants was conducted by the principal investigator (PI; first author). They received detailed written instructions on the audit tool usage and an assessment manual. The PI further demonstrated use of the audit tool and explained the interview schedule. This was then followed by a feedback session to clarify any issues. Thereafter, research assistants conducted the audits and interviews independently. Random inspections were made to ensure that the audits and interviews were conducted properly. Permission to conduct the audit was sought from the RC managers before proceeding with the systematic observation, which was performed inside the RC premises and the surrounding area and took approximately 90 minutes to complete. Informed consent was obtained from each participant before the face-to-face interview. The research protocol was approved by Curtin University Human Research Ethics Committee (approval number: HRE2016-0366) and registered on the Australian and New Zealand Clinical Trials Registry (trial no: ACTRN12617001022358).

2.2. Audit Instrument

The 'Audit of Physical Activity Resources for Seniors' (APARS) is designed to objectively assess features of the building and surrounding areas as well as its facilities and activities. It has high inter-rater reliability, with some evidence of construct validity in assessing health-related resources in the environment [51], and has been previously used by our research team [52]. Older adults aged 50–65 years are frequent users of the RCs [42,43]. Therefore, the APARS tool was considered suitable for this assessment. The audit was adapted for the Singaporean context to identify facilities and activities (PA, nutrition and social) provided by the RCs. The audit tool assessed the presence of facilities, i.e., 'Exterior PA facilities', 'Inside PA and nutrition facilities', 'aesthetics', i.e., 'Exterior environmental

features' as well as 'Inside social activities'. RC health activities were classified as 'PA activities', 'social activities' and 'nutrition activities'. In addition, the profile of each centre was also constructed by gathering data on their characteristics and patrons as provided by the RC managers (see Table 2).

Table 2. Characteristics of Recreational Centres (n = 100).

Patrons	
Age: mean (SD), years	60 (10.3)
Female (%)	82%
No. of patrons per class: mean (SD)	30 (19)
Recreational Centres	
Building area: mean (SD), m^2	104.62 (1.92)
Involved in HPB initiatives (%)	80%
Duration of HPB involvement: mean (SD), months	14 (17.1)
Government funding for patron activities (%)	80%

HPB—Health Promotion Board; SD—standard deviation.

2.3. Face-to-Face Interview Recruitment

From the 100 audited RCs, 22 RC patrons (at least four participants from each district) were purposefully selected to participate in the interviews. All participants selected were women aged 50 years and over who were currently attending the RCs and residing within the respective neighbourhood. These participants were approached and consecutively recruited at the RCs. After obtaining their informed consent, interviews of approximately 30 minutes duration were conducted in a quiet private location outside the RC.

2.4. Interview Schedule

An interview schedule was developed (see Appendix A) to explore participants' perception of facilities and activities offered at the RCs. The interview asked what participants liked about the facilities and activities, what they did not like, and how these could be improved. Interviews were conducted by the trained research assistants in the most suitable language, which included English, Mandarin and other Chinese dialects.

2.5. Data Analysis

Descriptive statistics were used to profile the characteristics of the RCs and demographics of the participants, performed using the Statistical Package for Social Science version 25 [53]. Qualitative data from the interviews were translated from Mandarin or other Chinese dialects to English and transcribed within two weeks after interview. An inductive approach was adopted to analyse the data in order to identify emerging themes [54]. Transcribed data were coded by the PI to form common categories, supported by direct quotes from the de-identified participants. Transcripts and qualitative data analysis were managed using the NVivo software version 11 (QSR International Pty Ltd, Melbourne, Australia) [55].

3. Results

3.1. Profile and Audit of RC Facilities and Activities

The mean age of the RC attendees was 60 years and predominantly female (82%). The average building size of the RCs was 104.62 square metres (approximately 40% the size of a tennis court), and 80% of the RC managers had been involved in HPB initiatives for approximately 14 months. Eighty percent of these RCs received government funding for activities (see Table 2).

3.2. RC Facilities and Activities

As shown in Table 3, most RCs were located close to parks and gardens (83%), grassy areas (72%), had access to bicycle racks (73%) and coffee corners with benches (58%). Outside PA facilities included exercise/fitness stations (80%), basketball/badminton courts (60%) and bike paths (41%). Facilities inside the RCs included kitchen (36%), fitness space (26%) and nutrition and PA hard copy resources (41%). Nearby amenities included a coffee shop/food court (98%), medical/dental clinic (95%), bus stop and train station (94%), supermarket/wet market (92%), convenient store (92%), gym and community centre (84%), pharmacy (65%) and physiotherapist clinic (15%). Most centres (87%) offered PA classes, fewer offered nutrition classes (60%) and social activities (37%). On average, approximately eight PA classes were held per month, with walking (29.8%) and aerobics sessions (17.5%) being the most frequent activities, whereas only one nutrition class or social activity was offered per month.

Table 3. Facilities and activities at Recreational Centres (n = 100).

Exterior Environmental Features	
Presence of parks and gardens (within 400 m)	83%
Bicycle racks	73%
> 1 grassy area (> 6 m × 6 m)	72%
Coffee corner with benches	58%
Vegetable/fruit/spice garden	36%
Vending machines with healthy foods/drinks	33%
No obstruction on path to centre	97%
Adequate footpaths to centre	94%
≥ 1 exterior light outside centre	80%
Exterior Physical Activity Facilities	
Exercise/fitness stations	80%
Basketball/badminton courts	60%
Bike paths	41%
Inside Nutrition and Physical Activity Facilities	
Washing basin for food preparation	80%
Utensil/Stove/Wok/Induction cooker/Oven	46%
Health booklets or recipe handouts (PA and nutrition)	41%
Kitchen	36%
Fitness space	26%
Weights/resistance equipment	14%
Inside Social Facilities	
Open social lounge or living room area with television	79%
Projector	71%
Board and card games	55%
Dining room	35%
Library	27%
Interactive video games	8%
Nearby Amenities (< 400 m)	
Coffee shop/Food court	98%
Medical/dental clinic	95%
Bus stop and train station	94%
Supermarket/Wet market	92%
Convenient store	92%
Gym/Community centre	84%
Pharmacy	65%
Physiotherapist clinic	15%

Table 3. *Cont.*

Health Activities	
PA classes: mean (SD) per month	7.87(8)
No. of RCs offering PA classes (%)	87%
Walking	29.8%
Aerobics	17.5%
Qigong	16.2%
Others (ball games, flexibility, martial arts, piloxing and yoga)	7.5%
Dance	7.0%
Tai chi	7.0%
Resistance training (resistance band)	5.0%
Nutrition classes: mean (SD) per month	1 (1.15)
No. of RCs offering nutrition classes (%)	60%
Cooking demonstrations	75.8%
Nutrition talks	24.2%
Social activities: mean (SD) per month	1 (3.19)
No. of RCs offering social activities (%)	37%
Mahjong	38.0%
Rummy O	33.3%
Bingo	28.6%

SD—standard deviation; PA—physical activity; Qigong—a holistic system of coordinated body posture and movement, breathing, and meditation; Mahjong—a tile-based game developed in China. It is commonly played by four players and is a game of skill, strategy and calculation; Piloxing—a system of exercise combining elements of Pilates and boxing; Rummy O—a tile-based game for two to four players based on matching tiles of the same rank or sequence and same suit; Tai chi—an ancient Chinese discipline of meditative movements, practiced as a system of exercises.

3.3. Face-to-Face Interviews

A total of 22 female RC patrons (mean age 65 years) consented to be interviewed. As shown in Table 4, they were predominantly of Chinese descent (96%), had a partner (96%), achieved primary school education (55%) and resided approximately seven minutes walking distance from their RC. The majority of them attended RC programs on a weekly basis (59%).

Table 4. Profile of interviewed patrons (n = 22).

Age: mean (SD), years	65 (8.8)
Ethnicity, n (%)	
Chinese	21(95.5%)
Malay	1 (4.5%)
Marital status, n (%)	
With partner	21(95.5%)
Without partner	1 (4.5%)
Education level, n (%)	
Primary school	12(54.5%)
Secondary school	8 (36.4%)
University	2 (9.1%)
Distance from residence to centre: mean (SD), walking mins	7.39 (6)
Frequency of attending Recreational Centre, n (%)	
Daily	6 (27.3%)
Weekly	13 (59.1%)
Monthly	3 (13.6%)

SD—standard deviation.

Feedback from participants was grouped into two main categories: (a) RC facilities and activities (both positive and negative aspects); and (b) Suggestions to improve facilities/activities. Supporting quotes from individual participants (P#) are provided below the identified themes when appropriate.

3.4. RC Facilities and Activities

3.4.1. Positive Aspects

Most participants commented that the RCs were conveniently located and met their needs—providing a place to engage with their neighbours and increase their social interaction opportunities.

> *"It is just a stone's throw from home . . . . I go to enjoy the facilities . . . ".* (P17)

> *"In the past, I did not really know my neighbours, did not interact much... But with the availability of the coffee corner (at the RC), I use the facility to interact . . . to make more friends".* (P20)

Participants enjoyed the range of activities and described reasons for their continued participation and attendance at the RCs. These reasons included improved mental health, increased social interaction with friends and family, and reinforcement of a healthy lifestyle.

> *"My qigong classes made me stay physically healthy and active".* (P12)

> *"Stretching classes gave me more time to spend with my husband".* (P14)

> *"I learn about using healthy cooking tips at home and when I am buying groceries".* (P17)

RC managers were nominated by the participants as playing a critical role in motivating their involvement in the activities offered.

> *"RC staff are very nice, approachable and friendly. I made friends with them as they frequently contacted and motivated us to attend upcoming events".* (P13)

> *"RC managers and volunteers do a good job to reach out to the community and benefitted me by increasing my social circle".* (P12)

3.4.2. Negative Aspects

Participants indicated that the limited floor area of the RCs made it difficult to accommodate more participants and restricted the facilities provided and the types of activities offered.

> *"Yoga classes are limited by the small facility where participants cannot do much with limited space".* (P4)

> *"Increasing space may cater to more participants, more activities and bigger events. More funding for communal space can accommodate more people for dance activities".* (P7)

Participants nominated several reasons that prohibited them from attending RC activities, such as lack of time due to personal commitments, lack of companionship, physical limitations, language barriers and financial difficulties in paying for the activities.

> *"I have limited time with family commitments and work occasionally elsewhere".* (P17)

> *"My schedule clashes due to caring for my grandchildren".* (P20)

> *"I prefer to speak my own dialects, i.e., Hokkien or Teochew".* (P11)

> *"Classes are too strenuous for us".* (P15)

> *"Each RC session costs US$2-$5 . . . . We would prefer 'free' sessions".* (P2)

3.5. Suggestions to Improve the Facilities/Activities

Participants proposed age-friendly indoor and outdoor safety fixtures (handrails, non-slip floors) and aesthetically pleasing spaces. Increased government funding to upgrade facilities was also seen as important.

"Facilities should be more user friendly, such as handrail, grab bar with slip resistant toilets". (P4)

"RCs can be beautified with more plants, flowers, herbs and spices". (P14)

"Government can enhance aesthetics of the RC, i.e., waterfall area, mini bonsai gardens and bear the cost of grab bars and slip resistant flooring". (P18)

Additional RC facilities suggested by the participants were diverse. These included a library, karaoke room, dance room, kitchen studio, reading corner and wellness centre.

"Some folks are very good at singing; a karaoke room can display their talent and boost their self-esteem". (P3)

"A dance room could keep us fit. By expanding the kitchen studio, more people can participate in cooking demonstrations". (P7)

Several participants indicated that activities should be social, of interest to them, and free of charge, with incentives seen as attractive motivators for RC participation. Preferred incentives included supermarket vouchers, discounts, reward cards, healthy food product samples, sports towels and Fitbits.

"Low cost educational tours are very enjoyable...we explored new culture, food and sights which foster relationships when travelling as a group". (P2)

"Sponsorship products such as nuts, sesame oil, wholegrain products can encourage healthy eating, or fitness gears to increase PA, such as a Fitbit". (P4)

"Government can provide RCs with discount cards, reward cards to use at healthier dining outlets". (P15)

Approaches to increase engagement with RC activities included matching of activities to participant's interests and abilities, involving family members, training multi-ethnic older volunteers to run activities, and linking external parties to share expertise.

"I love art and craft in making pretty and beautiful things using my hands". (P11)

"Retro or traditional Chinese music is good for dancing but at a slower pace for inactive people like me". (P15)

"Ensure most activities have focus on family members . . . cooking competition can involve the children, parents and grandparents together". (P7)

"Reach out to minority groups . . . . An older leader from different races could lead the fitness class or cooking session". (P19)

"Youth Executive Committee from community centres could be involved in planning of activities to inject more ideas". (P7)

Some participants expressed the need for the additional training of RC managers and more staffing in order to provide activities suited to their interests. Conversely, they also acknowledged that the RC staff do display a genuine interest in promoting healthy ageing initiatives.

"RC staff should be trained to show initiative, and enthusiasm in caring for the older people". (P4)

"RC staff could train participants on gardening as plants can be therapeutic for the mind and help to beautify the RCs". (P14)

"There should be annual seminars for RC staff to share best practices, innovative and successful initiatives in building a more caring community". (P4)

"We should reward RC staff who drive participants to attend wellness activities, such as health promoter of the month or best RC district manager in health advocacy". (P8)

4. Discussion

Despite the promotion of RCs as a recreational venue for older adults and the high demand for such community facilities to support healthy active aging in Singapore [45], there remains limited published information on the facilities and activities offered by RCs and their patrons' perception of these services [40]. With the exception of a small-scaled study of RC resources [45], the present study represents the first comprehensive report on this important topic.

There were several issues raised by the participants regarding the RC facilities. Firstly, the average floor space of the RCs was less than half the size of a tennis court, thus restricting the type of PA activities and facilities that could be offered. Space is limited in Singapore, which presents a challenging problem for RC managers to develop creative ways to manage the limited space available while servicing patrons. One solution may be to stagger activities for more patrons to increase access. The concern about limited space in RC indicates the necessity for government support to upgrade and expand RCs, to ensure the continuation of RC activities to meet the social and health needs of Singapore's ageing population. Eighty percent of the RC managers reported receiving government funding in the last 12 months, but the amount of such funding might not be adequate to upgrade facilities.

The audit revealed more opportunities to engage in PA within the RC environment than nutrition and social activities. The small-scale piloted study, undertaken in seven residential zones within one Singapore district (West region), similarly reported that PA was the main activity offered within RCs and their tendency to prioritise PA [45].

The importance of active lifestyle-enabling features for healthy ageing in cities is well recognised [56]. Examples of such features identified in the present study were hazard-free walkways with adequate lighting, outdoor facilities (park, fitness station, sports court, and bicycle rack) and nearby amenities (eateries, medical clinics, and efficient transport system). These environmental features will enable more PA opportunities, as evidenced in a cross-sectional study of 14 cities which showed increased PA in densely populated neighbourhoods with walkable interconnected streets, close amenities and parks [7]. In addition to these PA enhancing features, the patrons also provided suggestions to support their PA levels, such as "*attractive wall murals with 'get active' messages*", "*walking initiatives at nearby nature trails*" and the "*enhancement of aesthetics of the RCs through installation of a waterfall area or mini bonsai gardens*". These suggestions should be considered by the RC management.

The focus on PA is reasonable and acceptable, especially when considering that 61% of Singaporean adults are not meeting the PA guidelines of more than 150 minutes of moderate activity each week for health benefits [20], along with the positive health benefits associated with being physically active [57]. Activities such as walking are inexpensive, requiring no special equipment or skills and, when conducted in groups, can enhance social connectedness [58]. However, the promotion of healthy eating is equally important, since many Singaporean adults aged over 50 years have exceeded the recommended dietary allowance for energy, total fat, saturated fat and carbohydrates [19]. Our study found the RCs provided limited nutrition-related facilities and activities both inside (kitchen (36%) and kitchen appliances (46%)) and outside (vegetable/fruit/spice garden (36%), coffee benches (58%) and vending machines (33%) stocked with healthy snacks). To support healthy dietary behaviours, the social and physical features of the RC could be altered by environmental cues [10,11]. For example,

increasing the availability of healthier products in the vending machines would stimulate healthy snacking. RC managers could improve the aesthetic of the coffee benches and the kitchen to increase social interaction, provide healthy culinary courses for patrons, and develop community gardens. Community gardens, for instance, have many benefits that include developing social networks and friendships, increasing a sense of happiness and reducing stress through social interaction, improving access to fresh and nutritious vegetables [59], as well as replacing fast food consumption by fruit and vegetables [60]. A global meta-analysis confirmed the beneficial effects of gardening on mental wellness (depression, anxiety and life satisfaction), health outcomes (body mass index and quality of life) and general health [61]. The installation of community gardens is possible since 72% of the RCs were observed to occupy more than one grassy area (> 6 m × 6 m) outside their premises.

Based on the principles of the socio-ecological model and SCT concepts, the interaction of the interpersonal, physical environment and socio-cultural factors can either inhibit or facilitate engagement in health behaviours [46,62]. Several factors facilitated the engagement of patrons to utilise the RC, as reflected by their opinion: *"It is just a stone's throw from home"*, *"enjoy the facilities"*, *"use the facility to interact"*, *"make more friends"*, and *"stretching classes gave me more time to spend with my husband"*. On the other hand, factors that hindered their RC involvement should be addressed: *"prefer to speak my own Chinese dialect"* and *"classes are too strenuous for us"*. They also suggested a range of strategies to optimise engagement with RCs, such as increasing staff and volunteer training, recognition of staff commitment, involving families, provision of healthy incentives and considering patron's interests and abilities. Participants suggested alternative activities, such as *"making pretty and beautiful things with my hands"*, *"dance of slower pace to cater for the inactive participant"*, and *"gardening as plants are therapeutic and help to beautify the RCs"*. Age-friendly facilities such as the installation of handrails, non-slip floors, kitchen studio, dance and karaoke rooms were also proposed, which are worthy of consideration for future program planning. Moreover, the patrons nominated RC managers as playing a vital role in promoting health. A diverse range of adaptable facilities and customised activities should be provided at flexible times to keep them physically fit and socially active. Early involvement, consultation and engagement between managers and patrons should be encouraged to modify or refine facilities and activities, in order to motivate PA and dietary behaviour change. They further acknowledged the need for RC managers to be educated through annual seminars and be rewarded for their contribution. These findings can be used to better inform government to suit the RC patrons' changing physical abilities, demands and interests.

Future research should examine the impact of the RC activities and facilities on offer and their cost effectiveness in terms of reducing NCDs. Researchers could collaborate and innovate health promoting RC environments that are conducive to healthy aging. Comparisons between and within various RCs could be conducted to inform ways to manage resources more efficiently and promote best practice strategies and policies that reinforce and accelerate health-enhancing behaviours.

5. Conclusions

The capacity for the physical and social environment to positively influence PA and dietary habits has been well documented. This study revealed that RC facilities and activities primarily placed a greater emphasis on PA and less on healthy eating practices. The positive and negative aspects of RCs nominated by patrons should be reviewed by RC managers, along with their suggestions to improve the activities and facilities when promoting health behaviours. In particular, the provision of aesthetically pleasing RC environments, monetary incentives and healthy refreshments were highly recommended by RC patrons to motivate them to stay active and eat well. RCs serve as desirable community hubs to enhance healthy behaviours through appropriate activities and social connectedness. Collaboration between managers and patrons is paramount in making the RC facilities and activities relevant and supportive of active participation in healthy lifestyles. RC patrons have reported a strong interest in programs that focus on building social ties with their families and peers, while regarding RC managers as positive role models in encouraging them to sustain behavioural changes. The development of

policy to regularly assess and modify the RC environment could positively instigate PA and healthy eating practices to address the high rates of chronic diseases in Singapore.

6. Limitations

The present study represents the most comprehensive report on RCs in Singapore. The interviews were undertaken with female patrons because they constituted the predominant users of RCs (82%). It would be of interest to find ways on how to attract more men to RCs. The qualitative analyses were based on 22 interviews. Future surveys should be undertaken on a large number of participants across RCs to confirm our findings. In addition, once recorded, the interviews were translated from Mandarin and Chinese dialects into English, which might induce minor impacts on our interpretations. Since the study focused on specific types of services in a specific socio-geographical context, the generalisability of the findings is somewhat limited. Finally, future research should consider using cluster randomisation (i.e. same percentage of RCs in each area) to ensure equal representation of RCs.

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Abbreviations

APARS	Audit of Physical Activity Resources for Seniors
HPB	Health Promotion Board
QALY	Quality-adjusted life-years
NCD	Non-communicable diseases
PA	Physical activity
PI	Principal Investigator
RC	Recreational Centre
SCT	Social Cognitive Theory
SD	Standard Deviation

Appendix A Interview Schedule

- What do you like about the facility/facilities?
- What do you like about the activity /activities?
- What activity/activities do you participate in?
- What Recreational Centre facilities would you will like to see more/less of? Why?
- What activities would you like to participate in more/less of? Why?
- Has the Recreational Centre facilities and activities benefited you?
- What do you think motivates you to use the Recreational Centre facilities?
- What do you think motivates you to participate in the activities?
- What do you think would make you more likely to use the Recreational facilities and the activities?
- What do you think Recreational Centre managers and volunteers could do to improve the current facilities and activities in the community?
- What suggestions do you have on how government or other agencies could help to improve the Recreational Centres to support the health status of residents?

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APPENDIX B - Publication 3

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Process evaluation of the 'Singapore Physical Activity and Nutrition Study'

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ABSTRACT

Introduction: The Singapore Physical Activity and Nutrition Study (SPANS) aimed to improve the physical activity (PA) and nutrition behaviours of Singaporean women aged 50 years and over. The SPANS program consisted of PA classes, nutrition workshops, telephone dietary counselling, health booklets, a health calendar and program ambassadors. This study aimed to assess and understand the implementation of the program strategies and gain insight into process evaluation components to inform future programs.
Methods: The evaluation was guided by a process evaluation framework and collected data via questionnaires (n = 209), program ambassador documentation and exit interviews with program completers (n = 13) and non-completers (n = 12).
Results: In total, 295 participants completed the program (response rate = 84 %). Participants reported high levels of satisfaction with the overall program (99.5 %) and program activities (96.7 %), and also rated program ambassadors highly. Participation rates were highest for telephone dietary counselling sessions. The main reason for not attending program activities was having a 'busy schedule' (n = 158). Participants cited a need for improved recreational centre facilities and increased flexibility around program delivery.
Conclusions: The process evaluation showed that the program strategies were implemented as planned and were deemed suitable for supporting behaviour change among Singaporean women aged 50 years and over. The program reached and involved the majority of participants throughout the six months. The combination of practical educational resources and supportive program ambassadors were key strategies that facilitated positive PA and dietary behaviours. However, there needs to be some flexibility in the delivery of programs. The findings of this research may inform other programs in the region.

1. Introduction

The rising level of non-communicable diseases (NCDs) is a worldwide phenomenon. The World Health Organization (WHO) has called upon its 194 global members to intensify their physical activity (PA) and nutrition programs to reduce the rates of NCDs (World Health Organisation, 2017). The effectiveness of community-based PA and dietary programs aimed at combating NCDs is well-supported by evidence-based research (Blackford et al., 2017; Ding et al., 2016; Hyseni et al., 2016; Jancey et al., 2019).

In Singapore, NCDs account for 60 % of deaths (Dans et al., 2011), with a very high incidence of cancer, heart disease and type 2 diabetes (Epidemiology & Disease Control Division, 2019). Singaporean women aged 50 years and over are particularly at risk due to their unhealthy diet and insufficient levels of PA. Most women in this 'at-risk' group exceed the recommended intake for energy (58 %) and fat (57 %), do not meet the recommended dietary fibre requirements (62 %) (Health Promotion Board, 2013) and report high levels of leisure-time physical inactivity (72 %) (Ministry of Health, 2011).

In response to this, the Singapore Physical Activity and Nutrition Study (SPANS) was implemented to improve PA and dietary behaviours of Singaporean women aged 50 and over attending their neighbourhood recreational centres (RCs). RCs are public facilities that support social leisure activities and are located below high-rise public housing. They are conveniently located hubs for implementing lifestyle programs and facilitating lifestyle practices for older Singaporean women (Wong, Lee, James, & Jancey, 2019).

The SPANS program comprised (1) educational resources that included PA and nutrition booklets, a health calendar based on Singapore's PA and nutrition guidelines (Health Promotion Board,

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2015a, 2015b); (2) 12 PA classes (weeks 2–24); three nutrition education workshops (weeks 1, 12 and 24); and three telephone dietary counselling sessions (weeks 4, 12 and 20). These strategies supported lifestyle behaviour change as evidenced by previous PA and nutrition studies (Blackford et al., 2017; Burke, Jancey, Howat, Lee, & Shilton, 2013; Burke, Lee et al., 2013; Chee et al., 2017; Jancey et al., 2017; Jung, Lee, Lee, Kwon, & Song, 2012; Tran et al., 2017).

Trained program ambassadors (i.e., final-year nutrition, sports and wellness students (n = 13), qualified nutritionists (n = 2) and a certified fitness instructor (n = 1) organised and conducted the program strategies. They were responsible for the baseline and post-program data collection, as well as the fitting of accelerometers. The accelerometers measured PA levels objectively. They were worn by the participants on their right hip for seven consecutive days (pre- and post-program) and removed when showering, swimming and sleeping (Aguilar-Farías, Brown, & Peeters, 2014). A detailed overview of the accelerometer can be found in the published protocol paper (Wong, Lee, James, & Jancey, 2018). The control group participants received a falls-prevention booklet and were blinded to the nature of the program. The outcome evaluation results, currently under review elsewhere (Wong, Lee, James, & Jancey, 2020), have shown statistically significant improvements in moderate and vigorous-intensity PA and dietary behaviours in the intervention group compared to the control group.

This study presents the first report on a comprehensive process evaluation of the SPANS in Singaporean RCs. Previous research has argued that it is necessary to carry out a mixed-methods process evaluation to identify program characteristics and opportunities for improvements (Haynes et al., 2014; Liu et al., 2016; Moore et al., 2014). Process evaluation is widely used to determine if a program has been implemented as intended, to investigate reasons for attrition, to identify acceptability of a program and to provide insights into program outcomes (Lavinghouze & Snyder, 2013; Saunders, Evans, & Joshi, 2005; Shimazaki & Takenaka, 2015; Sranacharoenpong, Hanning, Sirichakwal, & Chittchang, 2009; Tran et al., 2017).

Involving participants and program ambassadors during process evaluation helps to ensure timely feedback, which improves program quality (Schijndel-Speet, Evenhuis, Wijck, & Echteld, 2014). Despite the many advantages of conducting process evaluation, the majority of lifestyle programs often neglect this form of evaluation, instead choosing to focus on impact and outcome evaluation (Olstad et al., 2016; Saunders, Wilcox, Baruth, & Dowda, 2014; Viester, Verhagen, Bongers, & Van Der Beek, 2014). Bauman and Nutbeam (2013) advised that process evaluation enables the researcher to determine if a program has been implemented as intended and identifies conditions that are needed to achieve successful program outcomes, which can then inform future programs. They concluded that if process evaluation is not conducted, researchers may not understand why a program was successful or unsuccessful. Therefore, this study aimed to assess and understand the implementation of the program strategies and gain insight into process evaluation components to inform future programs.

2. Methods

2.1. Setting and theory

This study describes the process evaluation of the larger SPANS program, a six-month randomised, controlled trial (RCT) targeting community-dwelling Singaporean women aged 50 and over who attended RCs across three Singaporean districts. The trial was registered with the Australian and New Zealand Clinical Trials Registry (trial no: ACTRN12617001022358), and details of recruitment and screening have been reported elsewhere (Wong et al., 2018).

Social Cognitive Theory underpinned the SPANS and was supported by several psychosocial constructs (Glanz, Rimer, & Viswanath, 2008). These constructs were (a) self-efficacy– participants were educated on the benefits of healthy eating and regular PA; (b) skill development– participants were encouraged to adopt and practice health-enhancing habits; and (c) positive reinforcement and observational learning through regular feedback and shared health experiences with other participants (Bandura, 2004; White, Wójcicki, & McAuley, 2012). Moreover, motivational interviewing strategies were implemented to positively influence PA and dietary behaviours (Cummings, Cooper, & Cassie, 2009; Rollnick, 2010).

2.2. Process evaluation design

The SPANS program adapted the process evaluation framework developed by Saunders et al. (2005) for assessing program implementation. This framework has been effectively used in comparable six-month PA and nutrition programs with older adults to pinpoint preferred strategies for facilitating behaviour change (Blackford et al., 2017; Tran et al., 2017). Process evaluation components based on Saunders et al.'s (2005) framework assessed (a) ways to attract participants and maintain their engagement (recruitment); (b) the number of active program participants (reach); (c) factors that affect implementation and outcomes (context); (d) the extent to which program implementation occurred as planned (fidelity); (e) the number of intended program strategies conducted (dose delivered-completeness); (f) the extent to which participants used resources as recommended (dose received-exposure); and (g) the satisfaction of participants with the program and staff (dose received-satisfaction). Table 1 is based on the Saunders et al. (2005) framework and summarises the process evaluation components and the corresponding data collection instruments.

2.3. Data collection procedure

The questionnaire and exit interview were adapted from previous instruments used in process evaluation studies (Blackford et al., 2017; Tran et al., 2017). Two trained program ambassadors pilot-tested the bilingual (English and Chinese) questionnaire (n = 10) and exit interviews (n = 5) with other peer-aged female RC patrons to improve their

Table 1
Process evaluation components and data collection instruments.

Process evaluation components	Data collection instruments		
	Self-completed questionnaires	Semi-structured exit interviews	Program ambassador documentation
Recruitment – ways to attract participants and maintain their engagement			X
Reach – number of active program participants	X	X	X
Context – factors that affect program implementation and outcomes	X	X	X
Fidelity – the extent to which program implementation occurred as planned			X
Dose delivered (completeness) – number of intended program strategies conducted	X	X	X
Dose received (exposure) – the extent to which participants used resources as recommended		X	X
Dose received (satisfaction)- the satisfaction of participants with program and staff	X	X	X

clarity and comprehension before administration to the target group. The measurement instruments were modified according to the respondents' suggestions (e.g., reduce the number of questions and simplify the structure of the questions). Conversely, the RC patrons commented that no changes were required for the exit interviews.

An information sheet with the researchers' contact details was provided to the participants. Program ambassadors informed participants of the study's purpose, objectives and procedure. A signed, informed consent form outlining the study's protocols and confidentiality was obtained from the participants prior to data collection. All program participants were invited to complete the questionnaire, and those participating in the interviews were purposefully selected. Both qualitative and quantitative data were collected.

2.4. Data collection instruments

2.4.1. Self-completed questionnaire

At the final PA session (session 12, week 24), participants completed a questionnaire that assessed the program and program ambassadors (i.e., clarity of presentations, delivery skills, approachability and knowledge) (see Supplementary File 1) and satisfaction with the program (i.e., activities, pace, sustainability and program overall). A five-point Likert scale (1 – poor, 2 – fair, 3 – satisfactory, 4 – good and 5 – excellent) was adopted to establish satisfaction with the program (i.e., pace and sustainability of interest) and program ambassadors (i.e., clarity of presentation, delivery skills, knowledge and approachability). Open-ended questions were included for participants to provide commentary on what they liked and did not like, as well as recommendations for program improvements.

2.4.2. Semi-structured exit interview

On completion of the program, exit interviews were conducted with program completers (n = 13) and non-completers (n = 12). The interview consisted of a 10-point Likert scale to assess the program ambassadors (1 = poor to 10 = excellent) and open-ended questions to determine (a) program engagement, (b) perception of program strategies, (c) support and guidance provided by the program ambassadors, (d) changes in attitudes and behaviours towards PA and diet and (e) suggestions for program improvements (see Supplementary File 2). Respondents opted for non-audio-recorded interviews. Therefore, the trained interviewers recorded participants' responses by hand. Recorded responses were then reviewed by the participants. Each interview lasted approximately 45–60 minutes was conducted in English or Chinese.

2.4.3. Program ambassadors' documentation

At the end of each PA class and nutrition workshop throughout the six-month program, a 15-minute group discussion was undertaken by program ambassadors. This process collected feedback relating to the program and its strategies and identified any issues that might impact attendance and acceptability of program strategies, together with recommendations for improvements. Recruitment and data collection challenges were documented throughout the program. Program ambassadors recorded participants' feedback after each session in their logbooks and reported this information to the principal investigator (PI), who monitored the feedback and responded to the need for any program modifications. Program ambassadors recorded participants' attendance at PA classes (n = 12), nutrition workshops (n = 3) and dietary counselling sessions (n = 3). Follow-up telephone calls were made to participants to identify reasons for their absence from any program sessions.

2.5. Analysis of data

2.5.1. Thematic analysis

Data collected via the self-completed questionnaires, exit interviews and program ambassadors' documentation were translated from the Mandarin or Chinese dialects into English. Thematic analysis of the transcribed qualitative data was conducted by two trained researchers. As guided by Braun and Clarke (2006), they familiarised themselves with the data, reviewed and coded the data, and established themes. Identified themes were supported by direct quotes from participants. Qualitative data from the questionnaire, exit interviews and program ambassadors' documentation were organised, sorted and managed using the NVivo 11 software (QSR International., 2017). The two trained researchers reviewed the data and reached a consensus.

2.5.2. Statistical analysis

Descriptive statistics were used to summarise participants' demographic profiles. For the self-completed questionnaire, responses to the five-point Likert scales (1 = poor to 5 = excellent) for the program and program ambassadors were recoded into dichotomous variables [unsatisfactory (1–2) and satisfactory (3–5)]. Percentages of dichotomous variables and attendance at sessions and workshops were calculated using the Statistical Package for Social Science software version 25 (IBM Corporation, 2017). Mean scores for the Likert scale rating (scale 1–10) for program ambassadors (i.e., nutritionists and the fitness trainer) were also calculated for the exit interviews.

3. Results

3.1. Participant demographics

In total, 295 Singaporean female residents aged 50 years and over completed the program, the majority of whom (mean age 64, SD 7.9 years) were of Chinese descent (96 %) and married (76 %) with high school education (54 %). About one-third (32 %) lived in four-room government flats (see Table 2).

3.2. SPANS program

3.2.1. Program withdrawal

Of the 351 participants who commenced the six-month SPANS, 295 completed the program (retention rate of 84 %). Reasons nominated by participants (n = 56) for withdrawing from the program included being busy with family, work and volunteer commitments (n = 38),

Table 2
Characteristics of female participants (n = 295).

Age mean (SD) years	64 (7.9)	
Chinese	282	95.7%
Malay	7	2.4%
Indian	6	1.9%
Education Level		
Primary or no education	71	23.9%
High/secondary school	160	54.1%
College	32	11%
University/tertiary education	32	11%
Marital Status		
With partner	223	75.6%
Without partner (widowed, single or divorced)	72	24.4%
Housing Type		
Government		
Two-room flat	14	4.8%
Three-room flat	58	19.6%
Four-room flat	95	32.1%
Five-room flat	54	18.2%
Private property	60	20.4%
Others (1 room, executive flats, maisonette)	14	4.9%

SD- standard deviation.

Table 3
Participation in program activities.

Telephone dietary counselling sessions (n = 3)	n	%
Session 1	212	89
Session 2	181	76
Session 3	182	76
Attendance level ≥ 75%	172	72
Nutrition workshops (n = 3)		
Workshop 1	189	79
Workshop 2	208	87
Workshop 3	172	72
Attendance level ≥75%	155	65
Physical activity classes (n = 12)		
Class 1	233	97
Class 2	171	72
Class 3	169	71
Class 4	183	77
Class 5	172	72
Class 6	188	79
Class 7	172	72
Class 8	172	72
Class 9	163	68
Class 10	168	70
Class 11	181	76
Class 12	163	68
Attendance level ≥75%	143	60
Attendance across all activities		
Attendance level ≥75%	157	66
Attendance level ≥50%	186	78

relocating overseas (n = 4), fear of blood tests (n = 4), uncontactable (n = 4), health issues (e.g., cataract, immobility and dizziness) (n = 3), relocation (n = 1), forgetfulness (n = 1) and death of spouse (n = 1). Non-completers reported that they participated for a period ranging from two to five months.

3.2.2. Program participation

The majority of participants (78 %) attended at least half of the PA classes and nutrition workshops, while 66 % attended at least three-quarters of the sessions. The highest participation rates were for telephone dietary counselling (72 %), followed by nutrition workshops (65 %) and PA classes (60 %) (see Table 3).

Participants (n = 295) reported several reasons that prevented them from achieving full participation at all sessions listed in Table 3. These included busy schedules (n = 158), time clashes with family activities, caretaking, working and volunteering (n = 32), overseas holidays (n = 17), health issues (n = 13), forgetfulness (n = 3), preference for PA to be conducted indoors (n = 3), fear of falling during wet weather (n = 3) and the belief that PA classes were tiring (n = 2).

The identified program themes were (a) program satisfaction, (b) program outcomes, (c) program improvements, (d) program resources and (e) program ambassadors (reported below).

3.2.3. Program satisfaction

Of the 295 participants, 209 (71 %) completed the questionnaire. A large majority of the participants reported high satisfaction rates for the overall program (99.5 %), program activities (96.7 %), program pace (96.7 %) and sustainability of program interest (96.2 %). The participants enjoyed the program, which increased their desire to improve their health. For example: *"I enjoyed the nutrition and fitness sessions, including the dietary counselling sessions, which motivated me to enhance my health" (Questionnaire 86)*. Almost all participants (99 %) reported that they would recommend the program to friends, family or other people: *"I will recommend the program to people who have the time to take part in it, as it is a good program to learn about healthy living" (Questionnaire 156)*. Even non-completers were satisfied and complimented the relevance of learning more about a healthy lifestyle. *"It was a good program to learn about healthy living. I would recommend it to people who have the time to take part in it (Interview 10)."* The program also provided opportunities for social support and time to bond with friends and family: *"… allows bonding with my sister and cousin that motivates me to change my diet" (Questionnaire 171)* and *"The fitness program pushed me to exercise and was also a good platform from which to get to know people" (Questionnaire 201)*.

3.2.4. Program outcomes

A sub-sample of participants was interviewed (n = 13) and reported that the SPANS had motivated them to increase their PA levels. More than half (n = 8) participated in PA sessions such as yoga, aerobics and dance classes (Flamenco, Performance, Bollywood, Zumba and Bokwa) offered elsewhere. Nine completers made dietary changes by eating less fried food, fatty meat, sugary food, meat, salt and oil and eating more whole-grains, dairy products, vegetables and fruit; while dining out less often. Some completers became motivated to search online for nutritional information on functional foods, calorie intake and food labels, with comments such as *"I seek knowledge online on reading labels, calories and functional foods" (Interview 10)* and *"when buying products in the supermarket, I look out for the healthier choice symbol" (Interview 11)*.

3.2.5. Program improvements

Participants recommended promoting the program via 'word of mouth' to friends and family members and they also emphasised sharing program benefits: *"… seniors can explain how healthy living has positively impacted their life" (Questionnaire 78)*. In addition, they suggested more frequent nutrition workshops (bi-weekly), bilingual language instructors and provision of refreshments and rewards (e.g., supermarket vouchers). Suggested future education topics included mental wellness and women's health issues.

Recommendations for PA classes included multiple timeslots and longer class durations (> 1 h): *"There could be more fitness classes per week for those who are busy on other days" (Interview 9)*. There were requests for more yoga and dance classes with guidance in posture correction, larger RC facilities for PA classes, a slower pace for inactive adults and videos of PA classes to take home. The need to eliminate participants' negative perceptions about wearing the accelerometer device (i.e., inconvenient, uncomfortable and visually unappealing) was highlighted. Participants suggested that program ambassadors should educate about the importance of the accelerometers in measuring PA levels and provide participants with personalised reports on their accelerometer data to improve their acceptance of wearing the device. The participants also perceived that dietary counselling was best conducted face-to-face rather than by telephone as a means of increasing rapport between the participant and the program ambassador.

3.2.6. Program resources

Overall, participants commented that program resources were valuable and that they used the educational resources as recommended: *"Good stretching exercises and the visual resources provided in the nutrition sessions facilitate understanding and were useful to learn about healthy living" (Interview 9)*. The information was found to be age-appropriate: *"I learned more about exercise and nutrition messages in this holistic program that suited my age group" (Interview 3)*. Participants found the resources to be easy to read and appealing and said they provided simple messages. For instance, *"The instructions in the health and recipe booklets*

are simple to follow" (Interview 13). "They are colourful, attractive and easy to read" (Interview 11) and "The recipes in the booklet were easy to cook yet tasted good … practical and helpful" (Interview 5).

3.2.7. Program ambassadors

Program ambassadors (i.e., nutritionists and the fitness instructor) were reported to be excellent educators with regards to their clarity during presentation (99 %), delivery skills (99 %), approachability (98.6 %) and knowledge (98.6 %). Participants stated that the ambassadors were highly suited to their roles with supporting quotes such as *"their energy level" (Questionnaire 112)*. Program ambassadors also scored highly on the 10-point Likert scale (mean = 8.4) in their teaching of PA and dietary information. They provided clear, simple and useful health information, with supportive quotes such as: "*It was helpful, and the presentation was short and sweet. Yet I gained good knowledge, and I am more aware of my health" (Interview 13)*. The ambassadors were also friendly, approachable and knowledgeable, with supporting quotes such as: "*Moves demonstrated by the fitness instructors are very good, professional and look very easy" (Questionnaire 89). "I felt that the trainers were encouraging … gained lots of knowledge that I found very beneficial for my blood circulation" (Questionnaire 210) and "the nutritionists were approachable and knowledgeable" (Interview 9)*.

4. Discussion

The process evaluation of the SPANS was conducted to assess and understand the implementation of the program strategies and gain insight into process evaluation components to inform future programs. The results demonstrated that the program was delivered as intended with appropriate program strategies and resources, supporting and motivating participants to change their PA and dietary behaviours.

The high retention rate (84 %) for the SPANS indicated good participant reach, adherence and acceptance of the program. Of those who withdrew from the program, the main reason was 'busy with family, work and volunteer commitments', which was consistent with comparable process evaluation studies of community-based PA and nutrition RCTs (Blackford et al., 2017; Burke, Jancey et al., 2013; Burke, Lee et al., 2013; Jancey et al., 2018; Tran et al., 2017). This is a challenging issue to address because individuals do have competing life priorities. There may be a need for more flexible approaches, such as encouraging home-based activities and resources. Home-based programs have been successfully used with older adults in other countries (Blackford et al., 2017; Burke, Jancey et al., 2013; Burke, Lee et al., 2013) but have not been trialled in Singapore, and this is something to investigate in the future.

An average attendance of 66 % was achieved across the program activities (i.e., PA classes, nutrition workshops and dietary counselling sessions), showing that these sessions were reasonably suitable outreach strategies for this target group. Nearly all participants were satisfied with the program activities, enjoyed the activities and were motivated to improve their health. Health benefits and social bonding with family and friends were key reasons that attracted the participants to maintain program engagement. Telephone dietary counselling achieved the highest participation rate, which makes it a priority strategy for future lifestyle programs. The motivational interviewing techniques used in the telephone discussions were well received and supportive of increasing positive behaviour change. Advantages of telephone counselling include convenience and the ability to provide prompt personalised feedback and reinforcement of positive behaviour change (Kim et al., 2013). This strategy also helps to counteract the main nominated barrier to attendance at the sessions and workshops, which was a busy schedule. Beyond this, some participants suggested face-to-face delivery for dietary counselling sessions as a means of strengthening rapport between participants and program ambassadors. Prior research into Asian lifestyle programs has found that face-to-face, personalised nutrition education increased program adherence and enhanced dietary changes (Chaiyasoot et al., 2018; Charunee et al., 2018).

The role of program ambassadors and the printed resources were also integral to the program. The program ambassadors played a crucial role in educating and motivating the participants to make positive behaviour changes, and the participants found the printed resources to be attractive, age-appropriate and easy to understand. The role of program ambassadors and the use of printed resources have been shown to be effective strategies in previous PA and nutrition studies with older adults (Blackford et al., 2017; Burke, Jancey et al., 2013; Burke, Lee et al., 2013; Jancey et al., 2018; Tran et al., 2017) and they appear to be suitable strategies for this target group of older Singaporean women.

The conveniently located RCs were an attractive venue, acting as a community hub to promote and increase leisure-time PA and healthy eating. As venues, RCs can increase social connectedness with other peer-aged participants by engaging them in health programs within their communities (Wong et al., 2019). However, the participants did identify the need to increase the size of RCs, as space constraints in the centres made implementing indoor health programs challenging. RCs are unique venues synonymous with Singapore, and they are popular and accessible (Heath et al., 2012; Wong et al., 2019). Therefore, more opportunities for increased investment in RCs to support healthy ageing are warranted.

One component of the program that was not well received was the use of accelerometers; many participants refused to wear the device. This challenge has been documented in previous studies, with participants refusing to wear a device due to discomfort, inconvenience, unappealing appearance and restriction in clothing choice (O'Brien et al., 2017; Huberty, Ehlers, Jonathan Kurkarbara, & Buman, 2015). As suggested by Tedesco, Barton, and O'Flynn (2017)), functional (i.e., unobtrusive, comfortable and effortless) accelerometers need to be designed to increase participants' acceptance and enthusiasm for wearing them. Those participants who did wear an accelerometer (n = 65) suggested leveraging off the accelerometer data through the provision of personalised reports on PA levels. This approach would provide feedback to the participants and potentially make the wearing of accelerometers more appealing.

Overall, the SPANS program was well received by the participants, and the program ambassadors' post-session feedback assisted in modifying the program to suit the participants' preferences and needs. For example, PA classes, nutrition workshops and telephone counselling were offered at alternative times to cater to busy participants. It is recognised that regular post-session reviews contribute to modifications to support the relevance and acceptability of the program to the target group (Lobo, Petrich, & Burns, 2014).

4.1. Strength and limitations

The main strength of this study was the fact that data were collected from multiple sources using both qualitative and quantitative methods, thus providing a comprehensive view of the implementation and acceptance of program strategies. However, social desirability and researcher bias might have affected the findings. Moreover, the participants might have been more motivated than those who chose not to participate in the program. Future research could explore whether these process evaluation components were sufficiently objective and adequately documented.

5. Conclusion

This study represents the first comprehensive process evaluation conducted on a program targeting older women in Singapore's recreational centres. The process evaluation demonstrated that the SPANS program was implemented as intended and engaged the majority of participants throughout the six-month program. The participants were satisfied with the program, resources and program ambassadors,

indicating the appropriateness of these strategies for this target group, particularly with regard to the use of the telephone for dietary counselling. The combination of practical educational resources and supportive program ambassadors were key strategies that facilitated positive PA and dietary behaviours. Participants' suggestions for program modification will be beneficial in the implementation of future programs, potentially increasing the relevance and suitability for older community-dwelling Singaporean women at risk of NCDs.

6. Lessons learned

Process evaluation is an essential part of program implementation. Such an evaluation should be undertaken to determine if the program was implemented as intended and to establish what worked and what did not work to understand why the program was successful or unsuccessful. Record keeping and participant involvement in process evaluation should occur at all stages of the program, and a variety of data collection tools should be used. Those implementing programs should keep communication channels with participants open and respond to participant feedback in a timely manner to improve program acceptability and maintain engagement. Data gathered at the end of each workshop and class over the course of the program supported timely feedback and program modification.

Author statement

- **Ms Elaine Wong Yee Sing** conceptualised, designed and pilot-tested the methodology and intervention, undertook recruitment, implemented the intervention program and was involved in managing and interpretation of the data collection, management and analysis.
- **Associate Professor Jonine Jancey** provided close supervision and monitoring of the research development, implementation and evaluation. She actively participated in the study, read drafts critically and suggested improvements for the publication.
- **Professor Andy Lee** provided statistical support and advice. He also participated in the study design and research process, read drafts critically and suggested improvements for the publication.
- **Dr Anthony P. James** provided advice, ongoing support and was involved in all stages of the research study and process. He read drafts critically and suggested improvements for the publication.

Authors' contributors

EYSW co-ordinated the study and drafted the manuscript. EYSW, JJ, AHL and APJ designed the study and revised the manuscript. All authors have contributed to the conception and design and/or the analysis and interpretation of data; draft the article or revise it critically for intellectual content; read and approved the final version for publication.

Availability of data and materials

Data and intervention materials are available from the first author upon request. Curtin University of Technology will have access to the final trial dataset, and there is no contractual agreements that limit its access for the investigators. Individual information will not be released owing to confidentiality agreements signed by the study participants.

Ethics approval, dissemination and consent to participate

The research protocol was approved by the Curtin University Human Research Ethics Committee (approval number: HRE2016-0366). The results of the study will be disseminated through reports, publications and conference presentations. Written informed consent was sought from all participants prior to entry into the study.

Trial registration

Australian and New Zealand Clinical Trials Registry, ACTRN12617001022358. Registered on 14 July 2017

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Declaration of Competing Interest

The authors declare that they have no conflicting interests.

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Appendix A. Supplementary data

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APPENDIX B - Publication 4

Original Article

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Effectiveness of a Singaporean Community-Based Physical Activity and Nutrition Intervention: A Cluster Randomized Controlled Trial

Elaine Yee-Sing Wong, MHSc[1], Anthony P. James, PhD[1], Andy H. Lee, PhD[1], and Jonine Jancey, PhD[1,2]

Abstract

This study examined the effectiveness of a 6-month intervention to improve the health behaviors and outcomes among women aged 50 years and older. A sample of 580 (intervention n = 295; control n = 285) women was recruited from 26 recreational centers. Only the intervention group participated in the Singapore Physical Activity (PA) and Nutrition Study (SPANS), received health resources (calendar, recipe, and booklets) and motivational support from program ambassadors. The intervention group showed significant improvements in moderate-intensity PA, vigorous-intensity PA, and total PA ($P < .001$), increased intake frequency of fruit and vegetables ($P = .049$), a reduction in salt and sugary beverage intake ($P \leq .042$), and reductions in systolic blood pressure (BP; −3.68 mm Hg), diastolic BP (−3.54 mm Hg), and percentage body fat (−2.13%; $P \leq .020$) when compared with the control group. The SPANS appeared to be efficacious in improving PA and dietary behaviors, reducing BP and percentage body fat among Singaporean women.

Keywords

ageing, anthropometry, blood tests, dietary habits, health promotion, noncommunicable diseases, physical activity, program ambassadors

What We Already Know

- Singaporean women aged over 50 years report high levels of leisure-time physical inactivity and less than half meet the recommended intake for fruit and vegetables.
- There is a scarcity of culturally appropriate evidence-based physical activity (PA) and nutrition interventions for Asian countries.
- Innovative strategies are needed to help Singaporean women (>50 years) to adopt health-enhancing nutrition and PA behaviors.

What This Article Adds

- To our knowledge, this is the first randomized controlled trial to determine the impact of a 6-month community-based PA and nutrition intervention for Singaporean women aged over 50 years.
- There were significant increases in PA levels (moderate, vigorous, total) and improvements in frequency of intake for fruit, vegetables, salty sauce, and sugary beverages.
- Recreational centers located below high-rise government housing provide an accessible local space to recruit older women and conduct PA and nutrition interventions.
- This successful intervention appears to be culturally appropriate for older Singaporean women.

Introduction

In Singapore, women aged over 50 years self-reported high levels of leisure-time physical inactivity (72%) and a high intake of saturated fat (67%) and sugary beverages (41%) in 2010.[1,2] Moreover, less than half of these women met the recommended serving guidelines for vegetables (26%) and

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fruit (34%). Due to these poor lifestyle practices, metabolic risk factors such as high blood pressure (BP), fasting blood glucose (BG) levels, and waist-hip ratio (WHR) are highly prevalent among these women.[2]

Evidence-based physical activity (PA) and nutrition interventions are well established for Western populations, but there is a scarcity of culturally relevant interventions for non-communicable diseases (NCD) prevention programs in Asian countries.[3-6] Considering Singapore's ageing population and the associated increase in NCDs, innovative strategies to help women adopt healthy lifestyles are required. Despite the Singapore government being committed to improving community health and addressing the risk factors for NCDs, targeted programs for women's health remain limited.[7]

Recreational centers (RCs) are public facilities located below high-rise government housing, where 80% of Singaporeans live.[8] Building healthier communities through facilities such as the RCs can create viable and convenient environments to initiate health-promoting opportunities for these women. Therefore, this study examined the effectiveness of a 6-month community-based intervention to improve the health behaviors (PA and diet), BP, anthropometric, and blood parameter outcomes among Singaporean women aged 50 years and over in RCs.

Methods

Study Design

Ethics approval was obtained for the 6-month community-based PA and nutrition cluster randomized controlled trial (RCT) from the Curtin University Human Research Ethics Committee. The Singapore Physical Activity and Nutrition Study (SPANS) protocol and design have been described in detail previously.[9] The screening, recruitment, and intervention period was staggered over 18 months, from October 2016 to March 2018, and posttest evaluation was completed in April 2018. The intervention was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) Statement; see Supplementary File 1, available online (CONSORT flow diagram), and Supplementary File 2, available online (CONSORT checklists).[10]

Participants

Following the research protocol, 61 RCs (intervention, n = 31; control, n = 30) located in 5 Singaporean geographical districts were randomly selected using computer-generated random numbers by the principal investigator (PI).[9] There was a minimum separation distance of 4 km to avoid the possibility of contamination between the 2 groups. Of the 61 RC managers who were invited to the study, only 26 (intervention [N = 14] or control [N = 12]) of them agreed to be involved in the study. For the intervention sites, the trained program ambassadors (final year nutrition, sports and wellness students, qualified nutritionists, and a certified fitness instructor) carried out the pretest and posttest assessment and the SPANS intervention. While at the control sites, the program ambassadors conducted only the pretest and postassessment.

Of those who were invited, 682 (intervention, n = 351; control, n = 331) agreed to participate and met the selection criteria: (a) female, aged 50 years and older; (b) did not meet the recommended PA guidelines (<150 minutes of self-reported moderate-intensity PA per week); (c) absence of a medical condition or poor mobility that prohibited their involvement in a PA program; and (d) not currently enrolled in other nutrition and PA research studies. All eligible participants (n = 682) who met the above-mentioned criteria completed the baseline assessment that included the Global PA Questionnaire–Short Form (GPAQ-SF).[11] Participants on medications (eg, glucose-lowering drugs) were eligible to participate in the intervention.

Procedure

Program ambassadors frequently liaised with the 26 RC managers to distribute the recruitment flyers and intervention resources and answered any enquiries related to the intervention. The flyers were promoted by the respective RC managers during the centers' activities and given to female patrons who met the selection criteria. Recruitment of participants was conducted through program flyers placed on the RCs' bulletin boards. Contact details of interested participants were recorded by the RC managers and provided to the program ambassadors. Participants were then contacted to assess their eligibility and informed of the study's purpose, confidentiality issues, and that they were free to withdraw at any stage. All participants were blinded to their intervention status. Only the program ambassadors and PI were aware of the group allocation.

Intervention

Social Cognitive Theory[12] complemented by motivational interviewing guided the development of SPANS and delivery of the program's educational and skill sessions, along with telephone support. Provision of feedback, reinforcement, skill-building, practice, and goal setting were program strategies to support positive behavior change. The SPANS program was developed by examining previously successful PA and nutrition strategies used in targeting older adults,[3-6] pilot-testing resources, and conducting formative evaluation with the target group. Program ambassadors introduced the program, distributed and explained printed resources (health calendar, PA and nutrition booklets, and recipe booklet) based on the Singaporean PA and dietary guidelines[13,14] to the intervention participants at the RCs. Participants were encouraged to engage in 150 minutes of moderate-intensity PA weekly and record their PA frequency and duration in the health calendar. They also attended nutrition workshops, telephone dietary counselling sessions, and low-intensity biweekly PA classes and they received text messages,

telephone follow-ups, and feedback from the program ambassadors. The components of the intervention were designed to motivate participants to undertake PA and maintain a healthy diet as a means of reducing risk factors of chronic diseases. Positive behavioral reinforcements through regular encouragement and feedback were facilitated by RC managers and program ambassadors. Furthermore, the interventions were conducted in RCs within the participants' neighborhoods to minimize participant burden. In contrast, the control group participants only received a falls prevention booklet. Intervention strategies and resources have previously been explained in detail.[9]

Measurement Instruments

A structured bilingual (English and Chinese) questionnaire was administrated face-to-face by the program ambassadors at baseline and postintervention to gather information on demographic and health characteristics. Details of the measurement instruments and outcome variables have been described elsewhere.[9]

Primary Outcome Variables

The *GPAQ-SF*, developed by the World Health Organization, has been validated for Singaporean adults.[11] It was used to measure self-reported PA (moderate-vigorous PA, walk and cycle PA, and total PA) and sitting time.

Accelerometers (ActiGraph GT3X; ActiGraph) objectively measured the duration (minutes daily) and intensity (moderate-vigorous) of PA including sedentary behavior (sitting time).[15] Acceleration was accumulated from 3 axes (vertical, mediolateral, anteroposterior) and combined into a vector magnitude score.[16] Participants with ≤4 days of 10 hours daily wear-time (excluding water-based activities) were included in the analysis. Non-wear-time was filtered from the raw data using the Troiano algorithm, based on ≥60 consecutive minutes of zero counts, with an allowance of up to 2 minutes of counts from 1 to 100.[16,17] Interested participants were given an information sheet on the accelerometer and the device was fitted to their right hip. Accelerometry data were collected and downloaded using 10-second epochs. Using the ActiLife 6 software (ActiGraph), the Freedson cut-off points for adults' estimated sedentary behavior (<100 counts per minute [cpm]), moderate-intensity PA (1952-5724 cpm), and vigorous-intensity PA (5725-9498 cpm).[16,17]

A modified STEPwise approach to *Surveillance Dietary Behaviour Questionnaire*, developed by the World Health Organization, was used to assess the frequent intake of fat, salt, sugary beverages, fruit, and vegetables.[18]

Fasting *blood samples* were collected to determine fasting BG, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, non-high-density lipoprotein cholesterol, cholesterol ratio, and triglyceride levels. They were measured, calculated, and compiled into reports at approved laboratories under the Singaporean Ministry of Health guidelines.[19,20]

Secondary Outcome Variables

Trained program ambassadors followed standard protocols to measure: (*a*) weight using a calibrated electronic scale and recorded to the nearest 0.01 kg; (*b*) height measured barefoot with a portable stadiometer to the nearest 0.1 cm and body mass index (BMI) calculated by dividing weight by the square of height (kg/m^2);[21] (*c*) percentage body fat taken without shoes and socks by an Endo Body Fat Composition Analyzer E-DBS908;[22] (*d*) waist circumference (WC) using a nonstretch tape, standing up at the midway level between the lowest rib margin and the iliac crest and recorded to the nearest 0.1 cm; (*e*) hip circumference (HC) at the widest circumference at the level of the symphysis pubis and gluteus maximus;[5] and (*f*) WHR calculated by dividing WC by HC. Systolic and diastolic BP were measured 3 times using an Omron electronic sphygmomanometer on the participant's upper arm at 1-minute intervals, while seated and the mean of the readings was recorded.[3]

Statistical Analysis

Descriptive statistics contrasted the baseline characteristics of the intervention and control groups. Comparisons between the groups were made across the baseline and posttest time points using χ^2 tests for dichotomous and categorical outcomes, and independent *t* tests and paired *t* tests for continuous outcomes. For variables with skewed distributions ([moderate, total, walk and cycle] PA, sitting time, BG, and triglyceride), Mann-Whitney *U* test, and Wilcoxon signed-rank test were applied instead.

To confirm any apparent association from the univariate analysis and to accommodate the inherent correlation of observations due to participants being nested within RCs, generalized estimating equations (GEE) models with exchangeable correlation structure were fitted to compare the outcome variables between the 2 groups from baseline to postintervention. The GEEs provided robust standard errors for the regression coefficients to adjust for the intracluster correlation, while accounting for the baseline magnitude of the measures and the effects of potential confounders (age, ethnicity, educational level, marital status, housing type, health conditions, medication usage, and clustering effect). These covariates were specified in the study protocol and based on comparable PA and nutrition interventions for older adults. All statistical analyses were performed at an individual level using Statistical Package for the Social Science version 25.[23] The sample size requirement of 240 participants per group[9] was met in this study, enabling 80% statistical power to detect a medium effect size of 10% improvement in PA prevalence by intervention participants relative to the control at a significance level of 5%.

Accelerometry data were obtained from the intervention group only. As most participants did not engage in vigorous PA, this variable was recoded into binary form to specify participation status (yes, no). Moderate PA, total PA, walk and cycle PA, and sitting time remained as continuous variables. For dietary behavior outcomes, fruit and vegetable consumption were classified as "frequent intake" if at least 2 servings were eaten daily, whereas salt and salty sauce consumption were classified as "frequent intake" if taken at least once per week. Sugary beverage and fatty food intake were classified as "frequent intake" if taken more than 3 times per week. Binary outcomes, such as vigorous PA, frequent intakes of fruit, vegetables, salt and salty sauce, sugary beverage, and fatty food intake, were analyzed using logistic GEE models, while normal GEE models with identify link and gamma GEE models with log link were applied to continuous outcomes exhibiting symmetric/normal and skewed empirical distributions, respectively.

Results

The final sample included 295/351 intervention (84%) and 285/331 control (86%) participants. The number of participants lost was n = 56 for the intervention group and n = 46 for the control group (see Supplementary File 1, available online [CONSORT figure for more details]). In addition, there were no missing data for all outcomes and covariates. There were no significant differences in the baseline characteristics between the intervention and control groups, except for age ($P = .005$). The intervention participants (mean age 64.5 years, standard deviation [SD] = 7.9) were slightly older than the control group (mean age 61.6 years, SD = 6.9). The majority of participants were of Chinese descent (95.3%), completed secondary school education (54.3%), were married (76.3%), and had existing health conditions (61.2%); see Table 1.

There were no significant differences in self-reported PA behaviors at baseline between the intervention and control groups. However, from baseline to posttest, significant increases were observed in the intervention group for moderate PA (65.2 metabolic equivalent of task [MET] minutes per week, $P < .001$), total PA (1123.5 MET minutes per week, $P < .001$), walk and cycle PA (187.5 MET minutes per week, $P = .002$), vigorous PA ($P < .001$), while sitting time did not change significantly ($P = .872$). No significant changes in self-reported PA behaviors were observed in the control group from baseline to posttest. At posttest, significant differences were observed between intervention and control groups for moderate PA ($P < .001$), vigorous PA ($P < .001$), and total PA ($P = .004$), but not for walk and cycle PA ($P = .558$) or sitting time ($P = .574$); see Table 2. Accelerometry data for the self-selected intervention participants (n = 65) from 10 RCs supported the findings of the aforementioned PA measures, with significant increases in moderate ($P < .001$), total PA ($P = .003$), but not for vigorous PA and sitting time between the 2-time points; see Supplementary File 3, available online.

There were no significant differences in measures of dietary behavior between the control and intervention groups at baseline. At posttest, significant improvements were observed in the intervention group for the frequent intake of fruit ($P < .001$), vegetables ($P = .018$), salt and salty sauce ($P = .031$), and sugary beverages ($P < .001$). But no differences were observed in the control group from baseline to posttest apart from a reduction in frequent intake of sugary beverages ($P < .001$). At 6-month posttest, statistically significant differences between the 2 groups were observed for frequent intake of fruit ($P < .001$), vegetables ($P = .027$), salt and salty sauce ($P = .026$), and sugary beverages ($P = .04$); see Table 2.

The diastolic and systolic BP in the intervention participants were found to be significantly improved postintervention with decreases of 3.54 and 3.68 mm Hg, respectively ($P < .001$). Conversely, the BP of participants in the control group slightly increased (ie, diastolic by 1.18 mm Hg, $P = .034$ and systolic by 1.26 mm Hg, $P = .184$); see Table 3.

The intervention group also exhibited small but statistically significant reductions in weight (0.57 kg), BMI (0.24 kg/m^2), and percentage body fat (2.13%; $P < .001$), whereas these parameters were unaltered in the control group. Significant improvements were also observed in the intervention group for measures of central adiposity (WC, HC, WHR). However, similar improvements were observed in the control group for WC and HC; see Table 3.

Fasting BG concentration significantly decreased during the study in both intervention (0.11 mM, $P = .027$) and control (0.19 mM, $P < .001$) groups, whereas their lipid profiles remained essentially unchanged except for a marginal increase in total cholesterol concentration in the control group (by 0.1 mM, $P = .041$); see Table 3.

After controlling for confounders and the inherent clustering, GEE analyses confirmed significant increases for moderate PA ($P < .001$), vigorous PA ($P < .001$) and total PA ($P < .001$), but not for walk and cycle PA ($P = .454$) or sitting time ($P = .190$) by the intervention group relative to the control group; see Supplementary File 4 and 5, available online. As for BP, anthropometry and blood parameter outcomes, significant reductions (baseline to postintervention) in the intervention group relative to the control group were only observed in systolic BP ($P = .020$), diastolic BP ($P = .001$), and percentage body fat ($P < .001$).

Logistic GEE analyses demonstrated significant improvements in the frequent intake of fruit ($P = .001$), vegetables ($P = .049$), salt and salty sauce ($P = .042$), and sugary beverages ($P = .019$) by the intervention group relative to the control group (see Supplementary File 5, available online). Moreover, the magnitudes of the estimated intracluster correlations for the various continuous and binary outcomes were all small (<0.07), indicating minimal effect due to the RC clusters.

Table 1. Baseline Characteristics of Intervention and Control Group Participants (N = 580).

Variables	Intervention group (n = 295)	Control group (n = 285)	P[a]
Age (years): mean (SD)	64.5 (7.9)	61.6 (6.9)	.005
50-55	50 (16.9%)	59 (20.7%)	
56-62	74 (25.1%)	99 (34.7%)	
≥63	171 (58.0%)	127 (44.6%)	
Ethnicity			
Chinese	283 (95.9%)	270 (94.7%)	.495
Malay, Indian, and others	12 (4.1%)	15 (5.3%)	
Education level			
Primary school/no education	66 (22.4%)	80 (28.1%)	.283
High/secondary school	167 (56.6%)	148 (51.9%)	
Diploma, university, and above	62 (21%)	57 (20.0%)	
Marital status			
Married	218 (73.9%)	224 (78.6%)	.184
Widowed, divorced, or single	77 (26.1%)	61 (21.4%)	
Housing type			
1-3 rooms	82 (27.8%)	68 (23.9%)	.522
4 rooms	89 (30.2%)	87 (30.5%)	
5 rooms and others[b]	124 (42.0%)	130 (45.6%)	
Health condition			
No	103 (34.9%)	122 (42.8%)	.051
Yes[c]	192 (65.1%)	163 (57.2%)	
Medication usage			
No	155 (52.5%)	166 (58.2%)	.126
Blood pressure	49 (16.6%)	44 (15.4%)	
Cholesterol	76 (25.8%)	70 (24.6%)	
Others[d]	15 (5.1%)	5 (1.8%)	

Abbreviation: SD, standard deviation.
[a]Chi-square test or independent *t* test between intervention and control groups.
[b]Executive flat (public housing at 130 m^2), Housing and Urban Development Corporation flats (hybrids of public and private properties), condominium (private housing with recreational facilities), and landed properties (eg, a semidetached house, terraced home, town house, shop house, or bungalow.
[c]Heart disease, stroke, high blood pressure, high cholesterol, diabetes, cancer, osteoporosis, arthritis, and others.
[d]Medication for cardiovascular disease, blood clotting disorder, asthma, thyroid, osteoporosis, diabetes, cancer, and Parkinson's disease.

Discussion

The SPANS intervention had a low attrition rate (15%), which may have been due to its acceptability and accessibility for the Singaporean women aged 50 years and older.[24] This compared favorably with similar PA and nutrition RCTs for older adults (19% to 22%).[3-6] The GEE analyses confirmed significant improvements in behavioral and health outcomes between the intervention and control groups. Such improvements were displayed in moderate to vigorous PA and total PA compared with the control group. These findings were supported by objectively measured accelerometry measurements (except for vigorous PA) taken from a subsample of the intervention participants (n = 65). Moreover, there were improvements in dietary behavior (increased frequent intake of fruit and vegetables, reduced frequent intake of salt and salty sauce, and sugary beverages). Furthermore, systolic BP, diastolic BP, and percentage body fat were significantly reduced over the 6-month period. These findings are similar to those reported in a limited number of primary prevention initiatives conducted in other areas of Asia, showing that culturally appropriate PA and nutrition interventions can effectively improve behavior and metabolic risk factors in older populations.[6,25,26]

Other anthropometric measures and the lipid profiles were not significantly altered relative to the control group. However, within-group improvements for the intervention group were observed for WC, HC, WHR, weight, and BMI. These improvements are consistent with those observed in other PA and nutrition intervention studies of similar duration.[3-6] However, no statistically significant within- or between-group changes in the fasting lipid profile were found. This may be related to the dose of PA performed in the SPANS intervention with a short PA intervention period (<60 minutes) and insufficient PA volume and frequency,[26] perhaps indicating a need for higher-intensity and longer-duration interventions. A systematic review of behavioral lifestyle RCTs also reported higher-intensity behavioral PA and dietary counselling exhibited greater improvements in anthropometric and metabolic risk factors.[27]

Table 2. Comparison of Self-Reported PA and Dietary Behavior Outcomes Between Intervention and Control Groups (N = 580).

Outcomes	Intervention group (n = 295)			Control group (n = 285)				
	Baseline, mean (SD)/n (%)	Posttest, mean (SD)/n (%)	P^a	Baseline, mean (SD)/n (%)	Posttest, mean (SD)/n (%)	P^b	P^c	P^d
Moderate PA (MET minutes/week)[e]	64.71 (54.46)	129.86 (150.07)	<.001	62.78 (54.62)	54.40 (64.08)	.064	.522	<.001
Vigorous PA, n (%)	18 (6.1%)	69 (23.4%)	<.001	9 (3.2%)	10 (3.5%)	.815	.093	<.001
Total PA (MET minutes/week)[e]	2767.43 (3254.51)	3890.93 (3671.38)	<.001	3134.62 (3230.52)	3290.13 (3361.10)	.528	.057	.004
Walk and cycle PA (MET minutes/week)[e]	911.33 (1588.98)	1098.86 (1934.26)	.002	821.52 (1154.30)	842.44 (1137.39)	.428	.470	.558
Sitting time (minutes/week)[e]	1290.85 (978.18)	1243.04 (783.63)	.872	1279.16 (938.54)	1334.053 (904.33)	.071	.871	.574
Frequent fruit intake[f]	123 (41.7%)	171 (58%)	<.001	128 (44.9%)	122 (42.8%)	.613	.434	<.001
Frequent vegetables intake[f]	169 (57.3%)	197 (66.8%)	.018	149 (52.3%)	165 (57.9%)	.178	.226	.027
Frequent salt and salty sauce intake[g]	230 (78%)	207 (70.2%)	.031	214 (75.1%)	223 (78.2%)	.323	.413	.026
Frequent sugary beverages intake[h]	55 (18.6%)	28 (9.5%)	<.001	53 (18.6%)	43 (15.1%)	<.001	.988	.040
Frequent fat intake[h]	90 (30.5%)	80 (27.1%)	.375	88 (30.9%)	80 (28.1%)	.383	.923	.798

Abbreviations: PA, physical activity; SD, standard deviation; MET, metabolic equivalent of task.
[a]Wilcoxon signed-rank test or χ^2 test between baseline and posttest for the intervention group.
[b]Wilcoxon signed-rank test or χ^2 test between baseline and posttest for the control group.
[c]Mann-Whitney *U* test or χ^2 test between intervention and control groups at baseline.
[d]Mann-Whitney *U* test or χ^2 test between intervention and control groups at posttest.
[e]Nonparametric tests applied.
[f]At least 2 servings per day.
[g]At least once per week.
[h]More than 3 times per week.

Table 3. Comparison of Blood Pressure, Anthropometry, and Blood Parameter Outcomes Between Intervention and Control Groups (N = 580).

	Intervention group (n = 295)			Control group (n = 285)				
Outcomes	Baseline, mean (SD)	Posttest, mean (SD)	P^a	Baseline, mean (SD)	Posttest, mean (SD)	P^b	P^c	P^d
Systolic blood pressure (mm Hg)	132.25 (18.43)	128.57 (18.26)	<.001	125.98 (18.0711)	127.24 (17.52)	.184	<.001	.373
Diastolic blood pressure (mm Hg)	78.41 (10)	74.87 (9.60)	<.001	75.68 (10.31)	76.86 (10.15)	.034	.001	.015
Waist circumference (cm)	83.54 (9.45)	81.84 (9.26)	<.001	82.17 (9.35)	81.03 (9.84)	.003	.080	.306
Hip circumference (cm)	96.54 (7.61)	95.54 (7.44)	<.001	95.43 (7.51)	94.25 (7.97)	<.001	.078	.044
Waist-hip ratio	0.87 (0.07)	0.86 (0.07)	.010	0.86 (0.07)	0.86 (0.07)	.737	.407	.562
Weight (kg)	56.80 (9.21)	56.23 (9.11)	<.001	55.49 (8.91)	55.44 (8.94)	.770	.082	.293
Body mass index (kg/m^2)	23.35 (3.48)	23.11 (3.43)	<.001	23.02 (3.42)	23.00 (3.45)	.789	.249	.696
Percentage body fat (%)	32.71 (8.05)	30.58 (8.03)	<.001	29.93 (8.65)	30.23 (8.50)	.282	<.001	.612
Blood glucose (mM)[e]	5.21 (0.99)	5.10 (0.96)	.027	5.14 (0.85)	4.95 (0.91)	<.001	.148	.004
Total cholesterol (mM)	5.34 (0.97)	5.35 (1.06)	.828	5.48 (0.90)	5.58 (0.99)	.041	.070	.009
Low-density lipoprotein cholesterol (mM)	3.08 (0.86)	3.09 (0.91)	.782	3.30 (0.83)	3.29 (0.93)	.648	.001	.011
Non-high-density lipoprotein cholesterol (mM)	3.66 (0.92)	3.67 (1)	.975	3.77 (0.92)	3.84 (1)	.068	.178	.031
Cholesterol ratio	3.32 (0.87)	3.33 (0.89)	.727	3.37 (0.93)	3.39 (0.94)	.606	.442	.422
Triglyceride (mM)[e]	1.28 (0.60)	1.28 (0.58)	.393	1.23 (0.56)	1.26 (0.62)	.699	.281	.323
High-density lipoprotein cholesterol (mM)	1.69 (0.44)	1.69 (0.45)	.780	1.71 (0.44)	1.73 (0.42)	.126	.548	.208

Abbreviation: SD, standard deviation.
[a]Paired *t* test between baseline and posttest for the intervention group.
[b]Paired *t* test between baseline and posttest for the control group.
[c]Independent *t* test between intervention and control groups at baseline.
[d]Independent *t* test between intervention and control groups at posttest.
[e]Nonparametric tests applied.

Self-reported walk and cycle PA were not significantly different between groups at posttest, possibly due to a high percentage of intervention and control participants (89%) already walking or cycling at baseline. A similar nonsignificant result was observed in a study, where 78% of the Japanese participants were already walking or doing other PA at baseline.[28] Further increases in these modes of transport might not be feasible due to the densely built environment, hot-rainy weather, and a lack of cycling infrastructure, as reflected in a qualitative Singaporean study.[29] Moreover, there was no reduction in sitting time, which that has also been reported in similar studies.[3,5] This issue is deserving of attention through the trialing of future strategies to encourage less sitting time.

Self-selection bias was unavoidable but was minimized through allocation concealment throughout the trial. Although in hindsight, to ensure a more homogenous study group, the recruitment age could be restricted to <70. Self-reported PA and dietary practices might have introduced recall and response bias. However, participants were blinded to their group allocation, which reduced any differential in reporting of health behaviors, with the expectation that inaccuracies would be similar across both groups. Additionally, the program ambassadors and the principal investigator in charge of data collection were not blinded, which may have introduced some bias. Nevertheless, the positive PA and dietary behaviors and improvements in BP and percentage body fat offer a potential model for implementing PA and dietary intervention program with this Singaporean population. Since NCDs are largely preventable, there is an urgency to prioritize and investigate the applicability of such long-term primary interventions to address chronic diseases at a national level in this Asian population.

Limitations

The study was restricted to women aged 50 years and older. However, future research could be extended to Singaporean men to increase the study's generalizability. Due to resource constraints, the study was conducted only for 6 months. A longer follow-up assessment period could be considered to examine program sustainability and the effectiveness of behavioral changes over time. Furthermore, the subsample of the self-selected intervention participants who wore the accelerometers might have been more committed to PA, which could bias the PA outcomes. Although these devices were limited in number due to budgetary constraints, they provided objective measurements of the PA outcomes.

Conclusions

The SPANS program was associated with improvements in PA and dietary behaviors, as well as reductions in percentage body fat, systolic and diastolic BP, in the intervention participants when compared with the control participants over the 6-month intervention period. Given the high prevalence of NCD risk factors among Singaporean older women, adoption of desirable health behaviors through culturally appropriate lifestyle interventions, such as SPANS within supportive environments, could be an effective strategy to reduce the risk of NCDs and optimize the health status of the "at risk" insufficiently active ageing populations.

Authors' Note

EW had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Informed Consent

Written informed consent was sought from all participants prior to entry into the study. The informed consent for the current study is available from the corresponding author on reasonable request. Individual information will not be released owing to confidentiality agreements signed by the study participants.

Ethical Approval

The research protocol was approved by the Curtin University Human Research Ethics Committee (Approval Number: HRE2016-0366).

Trial Registration

Australian New Zealand Clinical Trials Registry (Registration Number: ACTRN12617001022358; Registered on July 14, 2017). https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=372984&isReview=true

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Supplemental Material

Supplemental materials for this article are available online.

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APPENDIX C: COPYRIGHT PERMISSIONS

1. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2018). Physical activity and nutrition intervention for Singaporean women aged 50 years and above: study protocol for a randomised controlled trial. *Trials*, 19(1), 257. https://dx.doi.org/10.1186/s13063-018-2562-2

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2. **Wong, E. Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2019). Recreational Centres' Facilities and Activities to Support Healthy Ageing in Singapore. International Journal of Environmental Research and Public Health, 16(18), 3343. https://dx.doi.org/10.3390/ijerph16183343

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3. **Wong, E.Y.-S.,** Lee, A. H., James, A. P., & Jancey, J. (2020). Process Evaluation of the Singapore Physical Activity and Nutrition Study. *Evaluation and Program Planning*, 83, 101847. http://doi:https://doi.org/10.1016/j.evalprogplan.2020.101847

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4. **Wong, E.Y.-S.,** James, A. P., Lee, A. H., & Jancey, J. (2020). Effectiveness of a Singaporean community-based physical activity and nutrition intervention: a cluster randomised controlled trial. *Asia Pacific Journal of Public Health.* https://doi.org/10.1177/1010539520977311

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APPENDIX D: STANDARD PROTOCOL ITEMS: RECOMMENDATIONS FOR INTERVENTION TRIALS (SPIRIT) CHECKLIST (RELATED TO PUBLICATION 1)

SPIRIT

STANDARD PROTOCOL ITEMS: RECOMMENDATIONS FOR INTERVENTIONAL TRIALS

SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description	Addressed on page number
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	1
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	2
	2b	All items from the World Health Organization Trial Registration Data Set	n/a
Protocol version	3	Date and version identifier	n/a
Funding	4	Sources and types of financial, material, and other support	15
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	1, 15
	5b	Name and contact information for the trial sponsor	1
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	n/a
	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	n/a
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	1, 4
	6b	Explanation for choice of comparators	2
Objectives	7	Specific objectives or hypotheses	2
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	4
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	1, 5
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	5
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	11, 14
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	6
	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	n/a
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	n/a
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	6 - 9
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	5, 12-14, Figure 1

2

Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	6
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	5-6
Methods: Assignment of interventions (for controlled trials)			
Allocation:			
Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	5
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	n/a
Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	n/a
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	6
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	n/a
Methods: Data collection, management, and analysis			
Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	7 - 9
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	n/a

Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	Appendices
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	14
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	14
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	n/a
Methods: Monitoring			
Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	n/a, Appendices
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	n/a
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	6
Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	n/a
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	16
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	n/a

Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	n/a
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	n/a
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	16, Appendices
Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	16
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	15
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	n/a
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	16
	31b	Authorship eligibility guidelines and any intended use of professional writers	n/a
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	Appendices
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	Appendices
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	n/a

*It is strongly recommended that this checklist be read in conjunction with the SPIRIT 2013 Explanation & Elaboration for important clarification on the items. Amendments to the protocol should be tracked and dated. The SPIRIT checklist is copyrighted by the SPIRIT Group under the Creative Commons "Attribution-NonCommercial-NoDerivs 3.0 Unported" license.

Appendix:

Item number 19: Data management

Details of data management were described in the PhD candidate's candidacy proposal. It is available from the first author upon request.

Item number 21a: Data monitoring

A data monitoring committee is not formed due to the limitations in resources i.e. manpower

Item number 27: Confidentiality

Details of data management including confidentiality were described in the PhD candidate's candidacy proposal. It is available from the first author upon request.

Item number 31c: Dissemination policy

If BMC Trials Open can consider this manuscript for publication, the authors will be granting public access to the full protocol, participant-level dataset, and statistical code.

Item number 32: Informed consent materials

These materials were attached as appendices in the PhD candidate's candidacy proposal. It is available from the first author upon request.

APPENDIX E: TIDieR CHECKLIST (RELATED TO PUBLICATION 3)

TIDieR
Template for Intervention Description and Replication

The TIDieR (Template for Intervention Description and Replication) Checklist*:

Information to include when describing an intervention and the location of the information

Item number	Item	Where located **	
		Primary paper (page or appendix number)	Other † (details)
	BRIEF NAME		
1.	Provide the name or a phrase that describes the intervention.	1-5	
	WHY		
2.	Describe any rationale, theory, or goal of the elements essential to the intervention.	1-2	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (Table 3, pg 7)
	WHAT		
3.	Materials: Describe any physical or informational materials used in the intervention, including those provided to participants or used in intervention delivery or in training of intervention providers. Provide information on where the materials can be accessed (e.g. online appendix, URL).	1-2	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (Table 4, pg 7-8)
4.	Procedures: Describe each of the procedures, activities, and/or processes used in the intervention, including any enabling or support activities.	2	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (Table 4, pg 7-8)

TIDieR checklist

	WHO PROVIDED		
5.	For each category of intervention provider (e.g. psychologist, nursing assistant), describe their expertise, background and any specific training given.	2	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (pg 3-7)
	HOW		
6.	Describe the modes of delivery (e.g. face-to-face or by some other mechanism, such as internet or telephone) of the intervention and whether it was provided individually or in a group.	9	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (table 4, pg 7)
	WHERE		
7.	Describe the type(s) of location(s) where the intervention occurred, including any necessary infrastructure or relevant features.	2	
	WHEN and HOW MUCH		
8.	Describe the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose.	2	https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-018-2562-2 (table 4, pg 8)
	TAILORING		
9.	If the intervention was planned to be personalised, titrated or adapted, then describe what, why, when, and how.	N/A	

	MODIFICATIONS		
10.‡	If the intervention was modified during the course of the study, describe the changes (what, why, when, and how).	N/A	
	HOW WELL		
11.	Planned: If intervention adherence or fidelity was assessed, describe how and by whom, and if any strategies were used to maintain or improve fidelity, describe them.	2, 5	
12.‡	Actual: If intervention adherence or fidelity was assessed, describe the extent to which the intervention was delivered as planned.	2, 5	

** **Authors** - use N/A if an item is not applicable for the intervention being described. **Reviewers** – use '?' if information about the element is not reported/not sufficiently reported.

† If the information is not provided in the primary paper, give details of where this information is available. This may include locations such as a published protocol or other published papers (provide citation details) or a website (provide the URL).
‡ If completing the TIDieR checklist for a protocol, these items are not relevant to the protocol and cannot be described until the study is complete.

* We strongly recommend using this checklist in conjunction with the TIDieR guide (see *BMJ* 2014;348:g1687) which contains an explanation and elaboration for each item.

* The focus of TIDieR is on reporting details of the intervention elements (and where relevant, comparison elements) of a study. Other elements and methodological features of studies are covered by other reporting statements and checklists and have not been duplicated as part of the TIDieR checklist. When a **randomised trial** is being reported, the TIDieR checklist should be used in conjunction with the CONSORT statement (see www.consort-statement.org) as an extension of **Item 5 of the CONSORT 2010 Statement.** When a **clinical trial protocol** is being reported, the TIDieR checklist should be used in conjunction with the SPIRIT statement as an extension of **Item 11 of the SPIRIT 2013 Statement** (see www.spirit-statement.org). For alternate study designs, TIDieR can be used in conjunction with the appropriate checklist for that study design (see www.equator-network.org).

APPENDIX F: ETHICS APPROVAL

Curtin University

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07-Nov-2017

Name: Jonine Jancey
Department/School: Health Promotion
Email: J.Jancey@curtin.edu.au

Dear Jonine Jancey

RE: Amendment approval
Approval number: HRE2016-0366

Thank you for submitting an amendment request to the Human Research Ethics Office for the project **A physical activity and nutrition interventi for Singaporean women aged 50 years and above: a community base randomised controlled trial**.

Your amendment request has been reviewed and the review outcome is: **Approved**

The amendment approval number is HRE2016-0366-02 approved on 07-Nov-2017.

The following amendments were approved:
Addition of a brief interview with the participants attending the recreational centres.

Any special conditions noted in the original approval letter still apply.

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a complet report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority

APPENDIX G: PARTICIPANT'S INFORMATION SHEET

Curtin University

Participant Information Sheet

HREC Project Number:	*11237*
Project Title:	*A Physical Activity and Nutrition Intervention For Singaporean Women Aged 50 years and above: A Community Based Randomised Controlled Trial*
Principal Investigator:	Elaine Wong Yee Sing
Version Number:	1 – Face-to-Face Interview
Version Date:	01/9/2016

What is the Project About?

This research aims to implement and evaluate a physical activity and nutrition intervention on Singaporean women, aged 50 years and above. For many older women, poor diet and low physical activity are increasing their risk of chronic diseases. By conducting appropriate lifestyle interventions at recreational centres, it will improve their physical and nutritional knowledge; provide them with the opportunity to develop skills to support behaviour change, and collectively help to prevent or control chronic diseases.

Who is doing the Research?

The research is being conducted by Elaine Wong Yee Sing, Associate Professor Jonine Jancey, Professor Andy Lee, and Dr Tony James through the School of Public Health at Curtin University of Technology.

Why am I being asked to take part and what will I have to do?

You have been invited to participate in this study because you are a women aged above 50 years old residing in a Housing Development Board and is currently attending programs at your local recreational centre. Please read this document carefully and ask any questions you wish. Do not sign this informed consent form unless you fully understand the nature of the study and any possible side effects.

You will need to participate in six months of physical activity and nutrition intervention at your local recreational centre. Pre and post health screening will be conducted before and after the programme. Blood pressure, blood glucose and lipid profile will be collected by nurses employed by a Ministry of Health (MOH) certified health screener. Measurement of body mass index, body fat percentage, waist circumference and waist-hip ratio including the fitting of an accelerometer and its management will be explained by a program ambassador. These measurements will take approximately an hour. In addition, you will have a face-to-face consultation with a program ambassador to complete a health survey questionnaire that will take approximately 20 minutes.

After that, you will attend 6 half-hour sessions of group nutrition education session and 6 half-hour monthly dietary counselling with a nutritionist. In addition, there will be 24 half-hour weekly walks led by program ambassadors. You will receive health booklets, as well as monthly follow-up calls from the program ambassadors to encourage you to engage and maintain healthy lifestyle practices.

Are there any possible adverse effects?

There is the possibility of discomfort with blood collection. It is important that you inform us if you experience discomfort and you need to keep in mind that you are free to withdraw from the study at any stage. Your comfort during the procedures is of more concern than our ability to collect the blood samples. In some people, slight bruising and tenderness may appear afterwards at the sites of blood collection. Bruising is only minor and the arm will return to normal in a matter of days.

Are there any benefits' to being in the research project?

As a consequence of taking part in this study, you will gain useful information about your health profile and your participation will also provide us with important data that helps us to investigate into the impact of lifestyle intervention on chronic disease prevention. As the chronic disease is the leading cause of death and disability in Singapore, the results from these studies will enable us to determine ways to reduce their incidence.

Who will have access to my information?

All information that you provide will be kept confidential and used only in this project. Electronic data will be password-protected and hard copy data will be in locked storage. The information we collect in this study will be kept under secure conditions at Curtin University research drive for 7 years after the research has ended and then it will be destroyed. You have the right to access, and request correction of your information in accordance with relevant privacy laws. The results of this research may be presented at conferences or published in professional journals and there will be no personal identifying information used in the publication or presentation of study results.

Do I have to take part in the research project?

Taking part in a research project is voluntary. It is your choice to take part or not. You are free to withdraw from the study at any stage. Please let us know you want to stop so we can make sure you are aware of any thing that needs to be done so you can withdraw safely. If you chose not to take part or start and then stop the study, it will not affect your relationship with Curtin University. If you choose to leave the study, we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you have any questions or concerns about our research study and would like to discuss the research further, please contact:

- Elaine Wong, Project officer by telephone on (81387834) or email at (yeesing.wong@student.curtin.edu.au).
- Associate Professor Jonine Jancey, Project Supervisor, on phone (08 9266 3807) or email (J.Jancey@curtin.edu.au).
- Professor Andy Lee, Project Supervisor, on phone (08 9266 9285) or email (Andy Lee (Andy.Lee@curtin.edu.au).
- Dr Tony James, Project Supervisor, on phone (08 9266 9285) or email (Andy Lee (T.P.James@curtin.edu.au).

If you decide to take part in this research, we will ask you to sign the consent form. By signing the consent form, it indicates that you consent voluntarily to participate in this research project, and have your health information used as described. It is also telling us that you understand what you have read and what has been discussed. Please take your time and ask any questions you have before you decide what to do.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number 11237). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

APPENDIX H: PARTICIPANT'S CONSENT FORM

Curtin University

Participant Consent Form: Face to Face Interviews

1. I have been given clear information (verbal) about this study, and have it explained to me in a language I understand.

2. I have had the opportunity to ask questions, and any questions I have has been answered to my satisfaction.

3. I have been given time to consider whether I want to take part. I understand that participation is voluntary and I am free to withdraw at any time.

4. I agree that research data gathered from the results of this study may be published, provided that I will not be identifiable.

5. I understand that I can request a summary of the findings after the research has been completed.

6. If I have any queries or concerns I know that I can contact:

- Elaine Wong, project officer by telephone on (81387834) or email (yeesing.wong@student.curtin.edu.au).
- Associate Professor Jonine Jancey, Project Supervisor, on phone (08 9266 3807) or email (J.Jancey@curtin.edu.au).
  Professor Andy Lee, Project hrec@curtin.edu.au.

I consent to take part in this research project.

_____
Name of Participant

_____
Signature of Participant

_____
Date

APPENDIX I: CONSORT CHECKLIST (RELATED TO PUBLICATION 4)

CONSORT 2010 checklist of information to include when reporting a randomised trial*

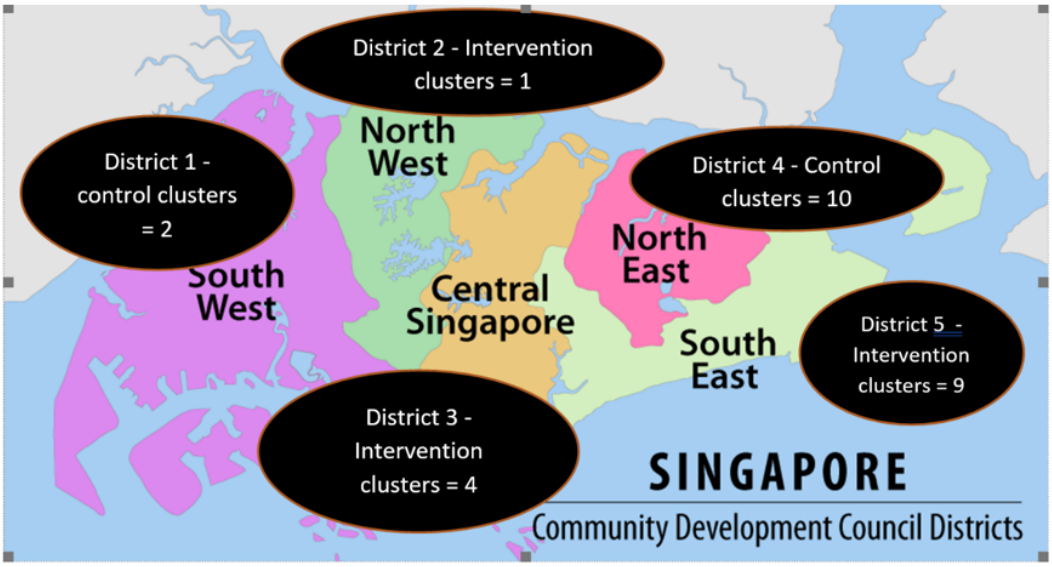
Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1,2
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	3-5
	2b	Specific objectives or hypotheses	5
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	N/A
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	N/A
Participants	4a	Eligibility criteria for participants	7
	4b	Settings and locations where the data were collected	6, study protocol- https://dx.doi.org/10.1186/s13063-018-2562-2 - page 3.
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	5, 8, study protocol– page 7-8.
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	9-11
	6b	Any changes to trial outcomes after the trial commenced, with reasons	N/A
Sample size	7a	How sample size was determined	10, study protocol– page 3-5.
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A

Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	6, study protocol-page 3).
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	N/A
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	6, in protocol paper- page 3.
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	6-7
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	7-8, study protocol - page 3.
	11b	If relevant, description of the similarity of interventions	N/A
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	9-11, study protocol, page 8-9).
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	6-7, Figure 1 (page 6), tables 1-3 (page 13-17, (Additional files 2-3.
	13b	For each group, losses and exclusions after randomisation, together with reasons	Figure 1.
Recruitment	14a	Dates defining the periods of recruitment and follow-up	5.
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Table 1 (page 13), Table 3 (page 17), Additional file 3.

Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	Figure 1, 1 and 12.
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Additional file 3.
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	N/A
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	N/A
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	21
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	21
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	N/A
Other information			
Registration	23	Registration number and name of trial registry	2
Protocol	24	Where the full trial protocol can be accessed, if available	Study protocol - page 2
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	23

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

APPENDIX J: DETAILS OF STUDY SITES



Legend:
District 1 – South West (Control RC clusters)
District 2 – North West (Intervention RC clusters)
District 3 – Central Singapore (Intervention RC clusters)
District 4 – North East (Control RC clusters)
District 5 – South East (Intervention RC clusters)

The South West district covers 17 areas with 115 RCs (District 1):

- Chua Chu Kang GRC comprising of Bukit Gombak, Chua Chu Kang, Keat Hong, Nanyang
- Jurong GRC comprising Jurong Central, Jurong Spring, Taman Jurong, Clementi, Bukit Batok East
- West Coast GRC comprising of Ayer Rajah, Boon Lay, Telok Blangah and West Coast
- SMCs of Bukit Batok, Hong Kah North, Pioneer and Yuhua

The North West district covers 19 areas with 106 RCs (District 2):

- Holland-Bukit Timah GRC comprising Bukit Timah, Cashew, Ulu Pandan and Zhenghua
- Sembawang GRC comprising Admiralty, Canberra, Gambas, Sembawang and Woodlands
- Nee Soon GRC comprising Chong Pang, Kebun Baru, Nee Soon Central, Nee Soon East and Nee Soon South
- Marsiling-Yew Tee GRC comprising Limbang, Marsiling, Woodgrove, Yew Tee
- SMC of Bukit Panjang

The Central Singapore district covers 21 areas with 164 RCs (District 3):

- Ang Mo Kio Group Representative Constituency (GRC) comprising Ang Mo Kio-Hougang, Cheng San-Seletar, Jalan Kayu, Sengkang South, Teck Ghee and Yio Chu Kang
- Bishan-Toa Payoh GRC comprising Bishan East- Novena, Bishan North, Toa Payoh- Balestier, Toa Payoh Central and Toa Payoh East
- Jalan Besar GRC comprising Kampong Glam, Kolam Ayer, Kreta Ayer-Kim Seng and Whampoa
- Tanjong Pagar GRC comprising Buona Vista, Moulmein-Cairnhill, Queenstown, Henderson-Dawson and Tanjong Pagar-Tiong Bahru
- Single Member Constituency (SMC) of Radin Mas, Sengkang West and Potong Pasir

The North East district covers 9 areas with 140 RCs (District 4):

- Aljunied GRC comprising Bedok Reservoir-Punggol, Eunos, Kaki Bukit, Paya Lebar and Serangoon
- Pasir Ris-Punggol GRC comprising Pasir Ris East, Pasir Ris West, Sengkang Central, Punggol North, Punggol Coast and Punggol West
- Tampines GRC comprising Tampines Central, Tampines Changkat, Tampines East, Tampines North and Tampines West
- SMCs of Hougang and Punggol East

The South East district covers 12 areas with 54 RCs (District 5):

- East Coast GRC comprising Bedok, Changi-Simei, Siglap, Kampong Chai Chee
- Marine Parade GRC comprising Braddell Heights, Geylang Serai, Kembangan-Chai Chee, Joo Chiat, Marine Parade
- SMCs of Fengshan, Macpherson and Mountbatten

APPENDIX K: LIST OF INTERVENTION RESOURCES

APPENDIX K: SPANS RECRUITMENT FLYERS

Intervention group

Control group

APPENDIX K: HEALTH CALENDAR

Health Promotion Board

Health Calendar 2016

New Year, New Resolutions.

Healthy living should be an everyday choice and you can take simple steps to adopt healthier habits in our daily lives. This Health Calendar has been specially designed to contain practical tips and healthier recipes to help you and your family kick-start to a healthier year ahead!

www.hpb.gov.sg
6435 3500

Useful Directory

Non-emergency Ambulance	1777
FOR CAREGIVERS	
AWWA Centre for Caregivers	6511 5310
ADA Dementia Helpline	6377 0700
CRISIS HOTLINES	
Samaritans of Singapore (SOS) 24-hour crisis hotline	1800 221 4444
IMH Crisis Helpline (Psychiatric Care and Treatment)	6389 2222
IF YOU NEED FINANCIAL HELP	
CareCare	1800 222 0000
OTHER HOTLINES	
Credit Counselling	6225 5227
HPB HealthLine	1800 223 1313
MUM-TO-BE Helpline	1800-MUM-TO-BE (1800 686 86 23)
HPB Smoking QuitLine	1800 438 2000

APPENDIX K: PHYSICAL ACTIVITY BOOKLET

Whether you are planning to start an exercise programme or become more physically active than you are now, you have taken the first step towards a healthier lifestyle. You can do a combination of lifestyle, aerobic and strength activities throughout the week. Design your own physical activity weekly plan and start today!

In Support of Sports Promotion

www.hpb.gov.sg
1800 223 1313

Physical activity: Some is better than none, more is better

Being physically active not only helps you look good and feel good, it also allows you to enjoy a healthy, vibrant life. No matter what your age or fitness level is, you can benefit from an active lifestyle.

Physical activity is any activity that makes you move your body. It includes activities such as taking the stairs, mopping the floor, walking to the store, jogging or playing a game like badminton.

According to the Health Promotion Board and the World Health Organization, regular physical activity:

- helps maintain and control weight
- keeps bones, muscles and joints strong
- increases lifespan and quality of life
- reduces stress and anxiety
- improves balance and coordination
- prevents falls
- reduces the risk of high blood pressure, heart disease, diabetes, stroke and certain cancers

The F.I.T.T. principle

The F.I.T.T. principle refers to the Frequency (F), Intensity (I), Time (T) and Type (T) of physical activity. It is a simple way to understand and apply the guidelines for physical activity.

Frequency (F): The number of times a physical activity should be done each week

Intensity (I): The level of difficulty of a physical activity (e.g. light, moderate, vigorous or hard)

Time (T): The duration of a physical activity in minutes

Type (T): The kind of physical activity selected

Amount and types of physical activity

There are basically three types of physical activity:

- Lifestyle activity
- Aerobic activity
- Strength activity

Lifestyle activity can easily be built into your daily life. It helps burn calories.

Lifestyle activity: Anytime, anywhere

Frequency: Daily

Intensity: Light to moderate

Light-intensity aerobic activities cause minimal increases in breathing and heart rate.

Moderate-intensity aerobic activities cause a noticeable increase in breathing and heart rate.

Time: Intermittent

Type:
1) Take the stairs regularly at the office, the mall and the MRT station
2) Walk to run errands located within your neighbourhood instead of driving or riding a vehicle
3) Alight one MRT stop or a few bus stops before your destination or
4) Park your vehicle further away from your destination and walk there

Also, break up long periods of inactivity lasting longer than 90 minutes with 5 to10 minutes of standing, moving around, or doing some physical activity.

Tip: If your lifestyle activity is performed at moderate-intensity and lasts longer than 10 minutes, it can count towards your recommended amount of aerobic activity.

Aerobic activity refers to an activity in which your large body muscles move in a rhythmic manner for a sustained period of time of at least 10 minutes. Such activities help prevent disease and add more healthy years to your life.

Aerobic activity: Aim for 150 minutes a week

Frequency: Spread throughout the week

Intensity: Moderate to vigorous (or a combination)*

Moderate-intensity aerobic activities cause a noticeable increase in breathing and heart rate. During the activity, you should still be able to talk but not have enough breath to sing.

Vigorous-intensity aerobic activities cause a large increase in breathing and heart rate. During the activity, you should still be able to say a few words but not be out of breath.

Another way of measuring intensity is to determine the heart rate with a heart rate monitor or by taking the pulse with the help of a wristwatch or timer. Refer to page 8 to find out more.

Time: For optimal health benefits, aim to accumulate 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity each week. Some individuals may need to accumulate 250 minutes a week to prevent weight gain.

* 1 minute of vigorous-intensity aerobic activity = 2 minutes of moderate-intensity aerobic activity
e.g. 10 minutes of jogging = 20 minutes of brisk walking

Type:
1) Moderate-intensity activities include brisk walking, dancing, doing low-impact aerobics, leisurely bicycle riding, playing golf, gardening, doing housework, playing a game like table tennis, etc.
2) Vigorous-intensity activities include jogging, brisk walking up a hill, doing step aerobics, swimming, playing a game like badminton, etc.

Check the weather forecast

- Check the weather forecast* first if you intend to exercise outdoors.
- Avoid outdoor activities on days with high temperatures and if there are signs of heavy downpour or lightning.
- Avoid exercising during the hottest part of the day, that is, 10:30am – 3:30pm.
- Consider wearing a cap or a hat and applying sunscreen to prevent sunburn when doing outdoor activities.
- Wear light, loose-fitting, "breathable" clothing.
- Prevent heat exhaustion and heat stroke by ensuring proper hydration.

Learn essential skills

- Equip yourself with emergency response skills such as First Aid, Cardio Pulmonary Resuscitation (CPR) and Automated External Defibrillator (AED) certification.

** Contact the Singapore Meteorological Station at 6542 7788 or log on to www.nea.gov.sg for weather forecast reports.*

Physical activity plan and you

Here is an example of how you can spread your lifestyle, aerobic and strength activities throughout a week:

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Take the stairs (L) Practise yoga (S) Stroll to the store (L)	Do 30-minute aerobic class at lunch time (M)	Take the stairs (L) Stroll in the mall after dinner (L)	Take the stairs (L) Lift weights (S) Brisk walk home for 15 minutes from the MRT station (L/M)	Swim for 20 minutes (V) Brisk walk 10 minutes after dinner (M)	Brisk walk 10 minutes to lunch venue (L/M) Dance for 30 minutes (M)	Do household chores (L) Jog 15 minutes in the park (V) Play a sport or a fitness game with family and friends (M/V)

L: Lifestyle activity
M: Moderate-intensity aerobic activity
V: Vigorous-intensity aerobic activity
S: Strength activity

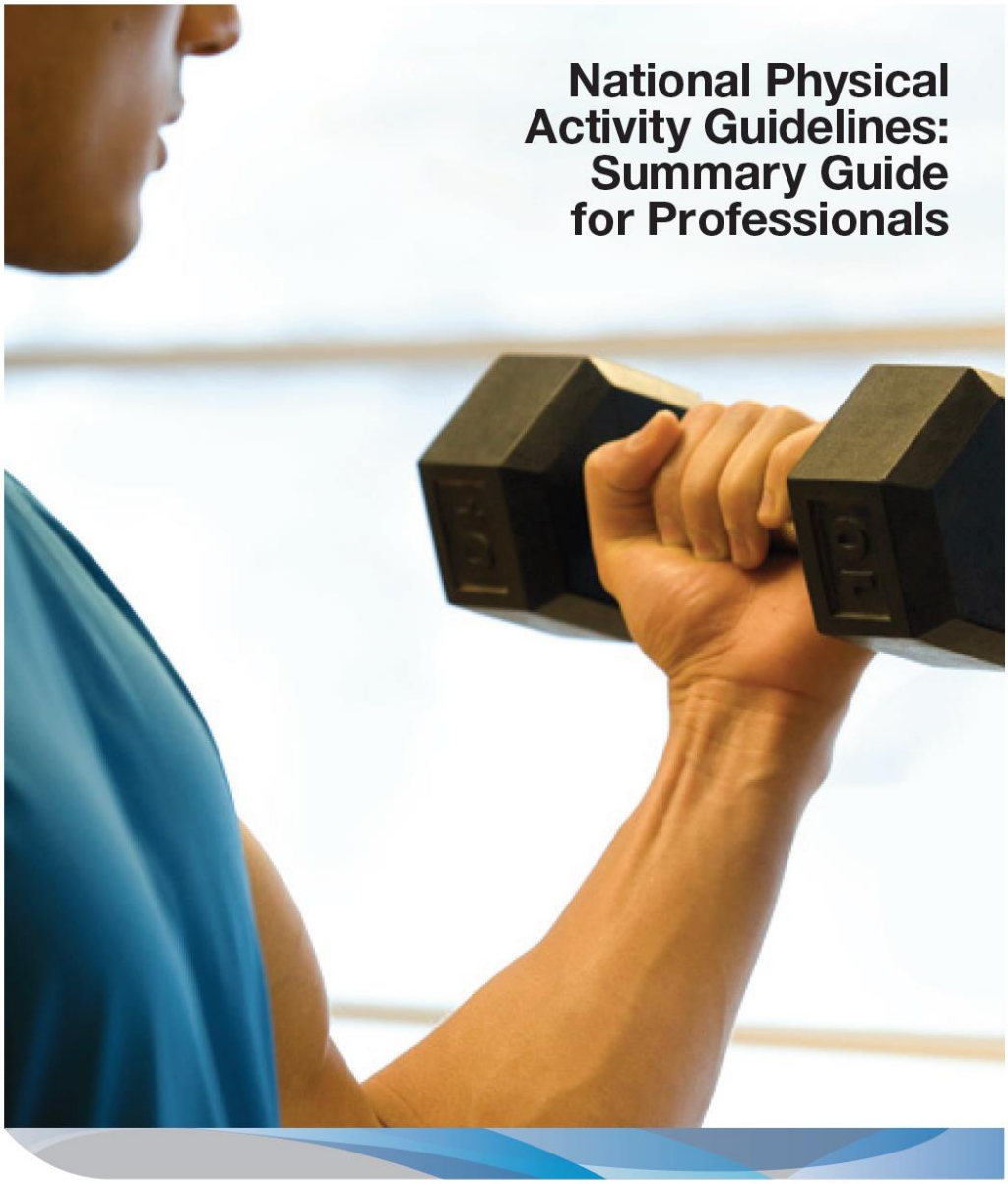
Design your weekly plan

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

You decide what works best for your weekly schedule!

APPENDIX K: NATIONAL PHYSICAL ACTIVITY GUIDELINES- SUMMARY GUIDE FOR HEALTH PROFESSIONALS

Health Promotion Board



www.hpb.gov.sg
1800 223 1313

National Physical Activity Guidelines

Physical inactivity has been identified by the World Health Organization (WHO) as the fourth leading risk factor for global mortality (6% of deaths globally). This follows high blood pressure (13%), tobacco use (9%) and high blood glucose (6%). Overweight and obesity are responsible for 5% of global mortality.

According to the recent 2010 National Health Survey conducted by the Ministry of Health, 39.1% of Singaporeans (18 – 69 years old) are physically inactive and 10.8% are obese.

The National Physical Activity Guidelines for Singapore provide practical guidance for apparently **healthy adults and older adults** on the types and volume of physical activities that prevent chronic disease, prolong life and enhance quality of life. The types of physical activity include **lifestyle**, **aerobic** and **strength** which can be performed in the domains of **work, home**, **commuting** or **leisure time.**

Definition

Physical activity is any force produced by skeletal muscles that results in energy expenditure above resting level.

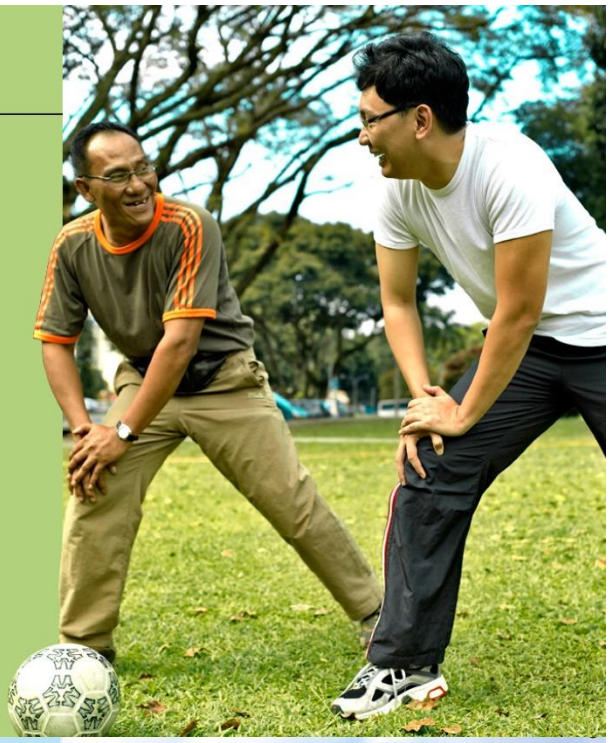
Key Message

Some physical activity is better than none, and more is better than some.

Stakeholders

The guidelines are useful to any stakeholders involved in promoting health and physical activity in Singapore including:

- ministries, statutory boards and councils;
- health promotion and public health workers;
- health professionals such as physicians, physiotherapists, nurses, dietitians and occupational health workers;
- polytechnic and university staff;
- local sports partnerships, sports trainers, coaches, health and fitness trainers, personal trainers and club volunteers; and
- Voluntary Welfare Organisations (VWO), community and grassroots volunteers.



Physical Activity Guidelines for Older Adults
(50+ Years Old)

Lifestyle Activity (every day)

Over a prolonged period of time, lifestyle physical activities may be useful to counter the small energy imbalance responsible for obesity in older adults.

Recommendations include:

- Taking the stairs regularly
- Walking to run errands instead of driving or riding
- Alighting one or more MRT/bus stops earlier, or parking further away than usual to walk to a destination
- Breaking up sedentary periods lasting longer than 90 minutes with 5 to 10 minutes of standing, moving around or doing some physical activity

Level 3 – Grade A

Aerobic Activity (spread throughout the week)

To acquire substantial health benefits, adults need to accumulate 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity per week. Individuals can combine vigorous-intensity and moderate-intensity activities, with 1 minute of vigorous-intensity aerobic activity being equivalent to 2 minutes of moderate-intensity aerobic activity.

Aerobic activity should be performed for at least 10 minutes per session. Combinations of moderate-intensity and vigorous-intensity aerobic activities can be performed to meet this recommendation.

Level 2 – Grade A

Strength Activity (2 or more days per week)

Strength activities provide additional health benefits. These include muscle-, bone- and joint-strengthening activities (e.g. using hand-held weights, resistance bands, callisthenics, strength-training equipment, carrying groceries and climbing the stairs) and some mind body exercises (e.g. Qigong, Tai Chi, yoga and Pilates). Strength activities should involve major muscle groups: legs, hips, back, abdomen, chest, shoulders and arms.

Level 2 – Grade A

Balance

In addition, balance ability may become a concern for some older adults as they age. Balance is maintained or improved by regularly following the physical activity guidelines for older adults.

Level 2 – Grade A

For older adults, a moderate-intensity aerobic activity causes a noticeable increase in breathing and heart rate eliciting a relative intensity rating of 5 – 6*.

For instance, older adults should still be able to talk but do not have enough breath to sing while engaging in brisk walking, ballroom dancing, low-impact aerobics, leisurely bike riding, playing golf or table tennis, gardening, doing housework, etc.

For older adults, a vigorous-intensity aerobic activity causes heavy breathing and increase in heart rate eliciting a relative intensity rating of 7 – 8*.

For instance, older adults should still be able to say a few words but are not out of breath while engaging in brisk walking up hills, jogging, step aerobics, swimming, playing badminton, etc.

**Relative intensity is rated on a scale of 0 to 10, where sitting is 0 and the highest level of effort possible is 10. A moderate-intensity activity is a 5 or 6 and a vigorous-intensity activity is a 7 or 8.*

Physical Activity Guidelines for the Prevention of Weight Gain and Obesity
(Adults & Older Adults)

Individuals who are overweight* should aim to reduce their weight and prevent obesity. There is strong evidence that regular physical activity reduces the risk of weight gain and is most effective when combined with a balanced diet.

Engaging in regular physical activity can provide substantial health benefits regardless of an individual's BMI classification (normal, overweight or obese). Regardless of BMI classification, physically active/fit individuals are more likely to live longer, and lead healthier lives than inactive/unfit individuals.

Guidelines

Initially, individuals should accumulate 150 to 250 minutes of moderate-intensity aerobic activity per week, while not exceeding caloric intake requirements. If necessary, individuals should adjust their aerobic activity and caloric intake to a point where it is individually effective for achieving a healthy body weight.

Some individuals may need to accumulate more than 250 minutes of aerobic activity per week to prevent weight gain. Individuals should progress gradually when increasing the volume of aerobic activity.

Level 2 – Grade A

Increasing daily lifestyle activities expends more calories and may aid in the prevention of weight gain.

Level 3 – Grade A

Muscle-strengthening exercises may promote loss of total body fat and mitigate intra-abdominal fat increase over time.

Level 2 – Grade B

Adults and older adults should aim to reduce body weight at an optimal rate of 0.5–1kg per week to achieve an initial weight loss goal of up to 10% from baseline.

A deficit of 500kcal per day below the estimated calorie requirement should result in a weight loss of about 0.5kg per week.

**The WHO defines overweight as body mass index (BMI) of 25–29.9.*

Points of Caution

Individuals who are planning to become more physically active than they are now should review the Physical Activity Readiness Questionnaire (PAR-Q) before they start.

Each aerobic and strength exercise session should include 5 to 10 minutes each of warm-up and cool-down segments and flexibility exercises. These flexibility exercises can be an integral part of one's weekly physical activity routine and may include mind body exercises.

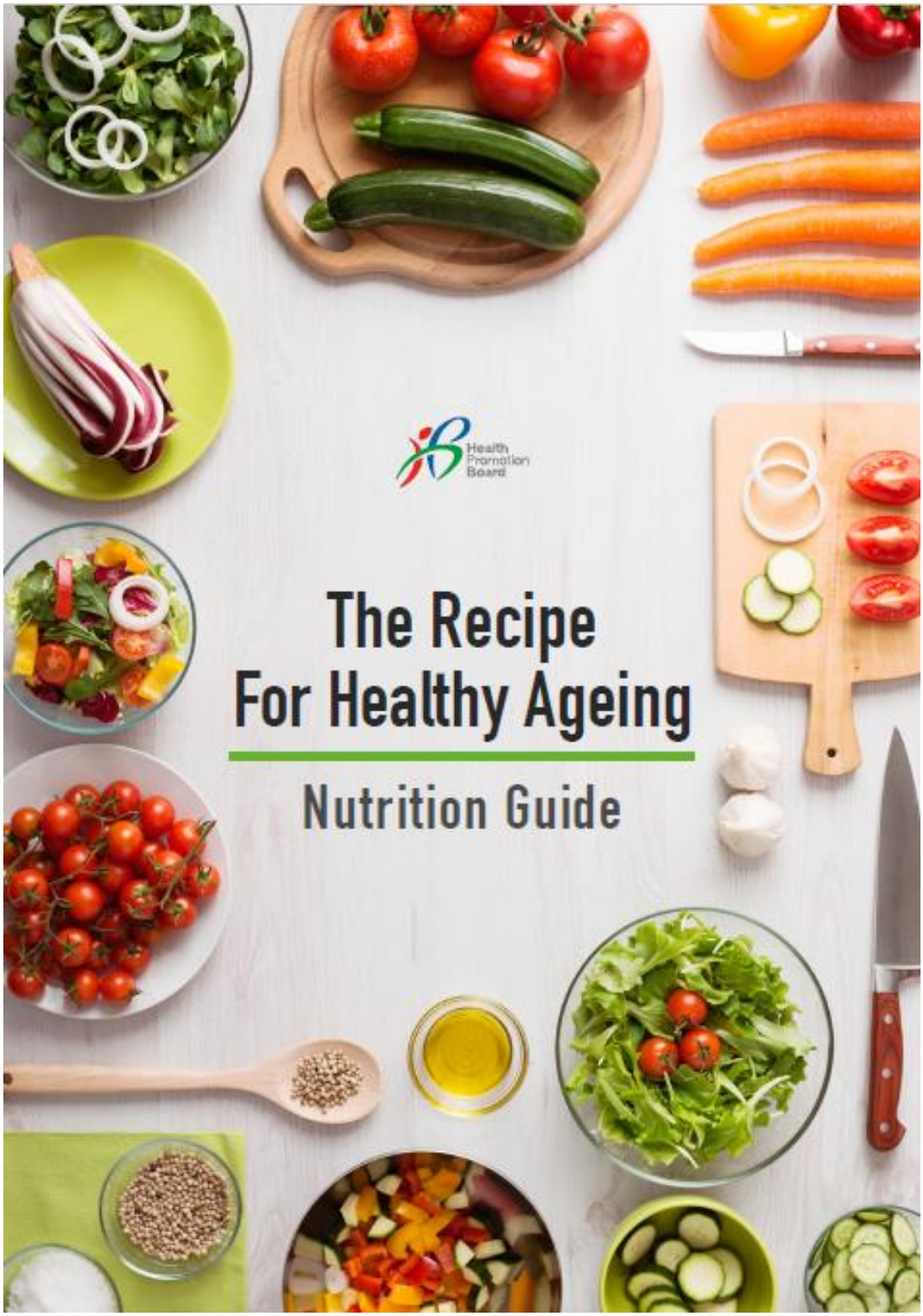
Individuals with limitations, disabilities or with chronic conditions should follow their doctor's advice on the volume and types of physical activities that are best for them.

Older adults who are concerned about the risk of falling should follow their doctor's advice for participating in physical activity programmes.

Older adults should be aware of their relative intensity effort (on a scale of 0 to 10) during physical activity.

Beginners should gradually work towards meeting the recommended physical activity guidelines.

APPENDIX K: NUTRITION GUIDEBOOK



Shopping list

Choose Healthier Choice Symbol Products where possible. Products with the HCS usually contain less total fat, saturated fat, sodium and sugar and may pack more dietary fibre, calcium and wholegrains compared to similar food products.

Include meat, fish or tofu

Provide protein essential for maintaining physical function and reducing muscle loss.

- [ ] Lean meat and poultry - remove skins and visible fat
- [ ] Fresh or frozen fish
- [ ] Eggs
- [ ] Tofu, taukwa, tempeh, beans and lentils
- [ ] Low-fat milk, low-fat cheese
- [ ] Low-fat yoghurt

Bone up on calcium

Maintain or build bone strength, muscle and nerve health.

- [ ] Low-fat milk
- [ ] Low-fat cheese
- [ ] Low-fat yoghurt
- [ ] High-calcium soybean milk
- [ ] Ikan bilis
- [ ] Sardines

Fill up on wholegrains, fruits & vegetables

Strengthens body's immune system and protects against diseases.

Wholegrains

- ☐ Brown rice, wholemeal bread, wholemeal noodles, brown rice bee hoon, chapati
- ☐ Wholewheat biscuits and crackers
- ☐ Oats

Fruit

- ☐ Any kind of fresh fruit

Vegetables

- ☐ Any kind of fresh or frozen vegetables

Lighten up on salt

Helps reduce risk of high blood pressure, stroke, heart and kidney disease.

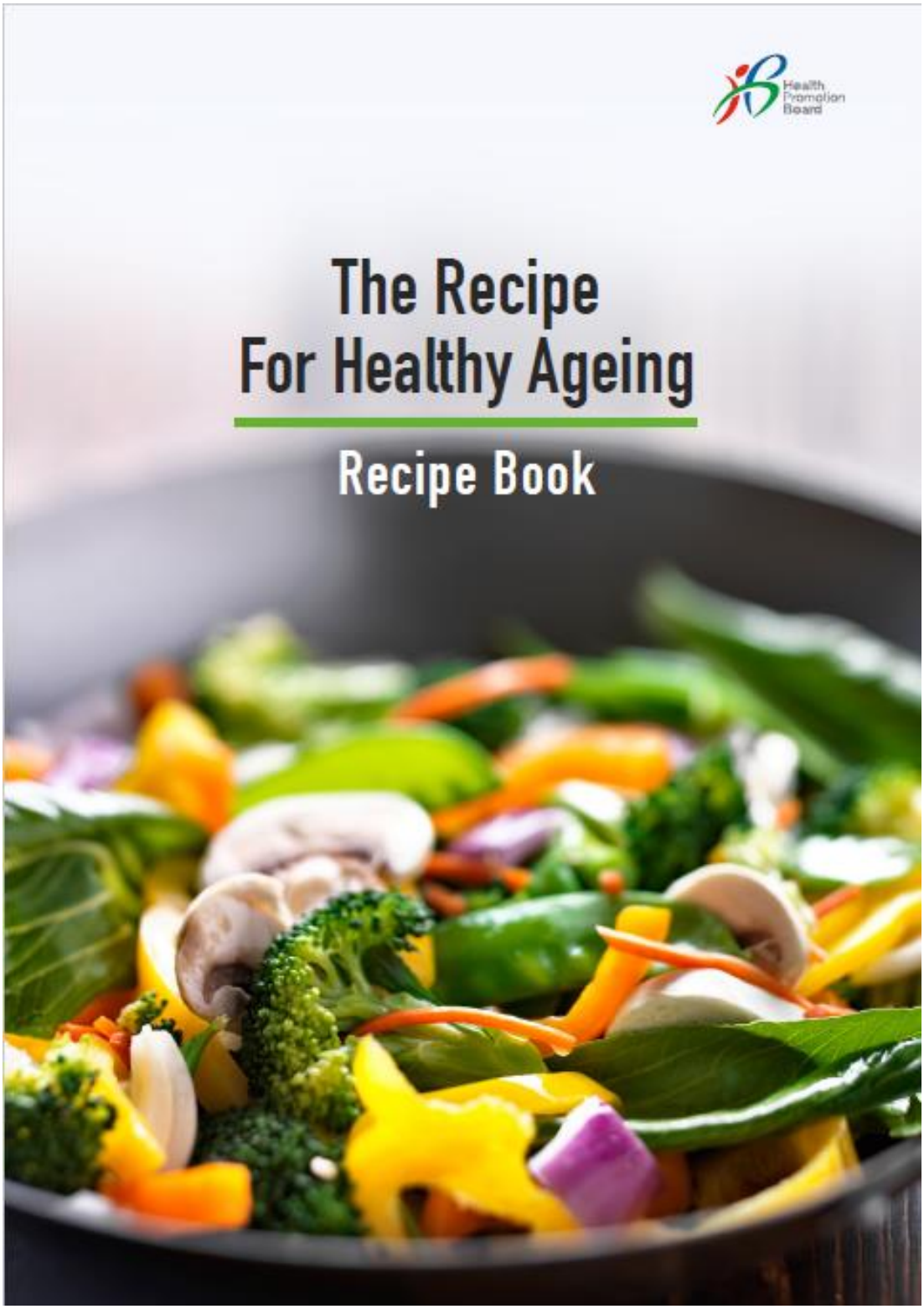
- ☐ Herbs and spices

Others

- ☐ Oils and margarine
- ☐ Water
- ☐ No sugar or reduced sugar drinks

APPENDIX K: NUTRITION POSTER

APPENDIX K: RECIPE BOOKLET



From Nutrition to Nourishment.

You know the science. It's time to savour the flavours.

In the Nutrition Guide, you've learned the right quantity and kinds of foods you should be eating based on My Healthy Plate and the importance of protein and calcium, in your diet. Here are the important points to remember:

Have meat, fish, or tofu in every meal – Look out for recipes with a palm, it meets your protein needs for that meal.

Bone up on Calcium – Look out for calcium stars in each recipe. Aim for 10 calcium stars a day.

Fill up on wholegrains, fruit and vegetables

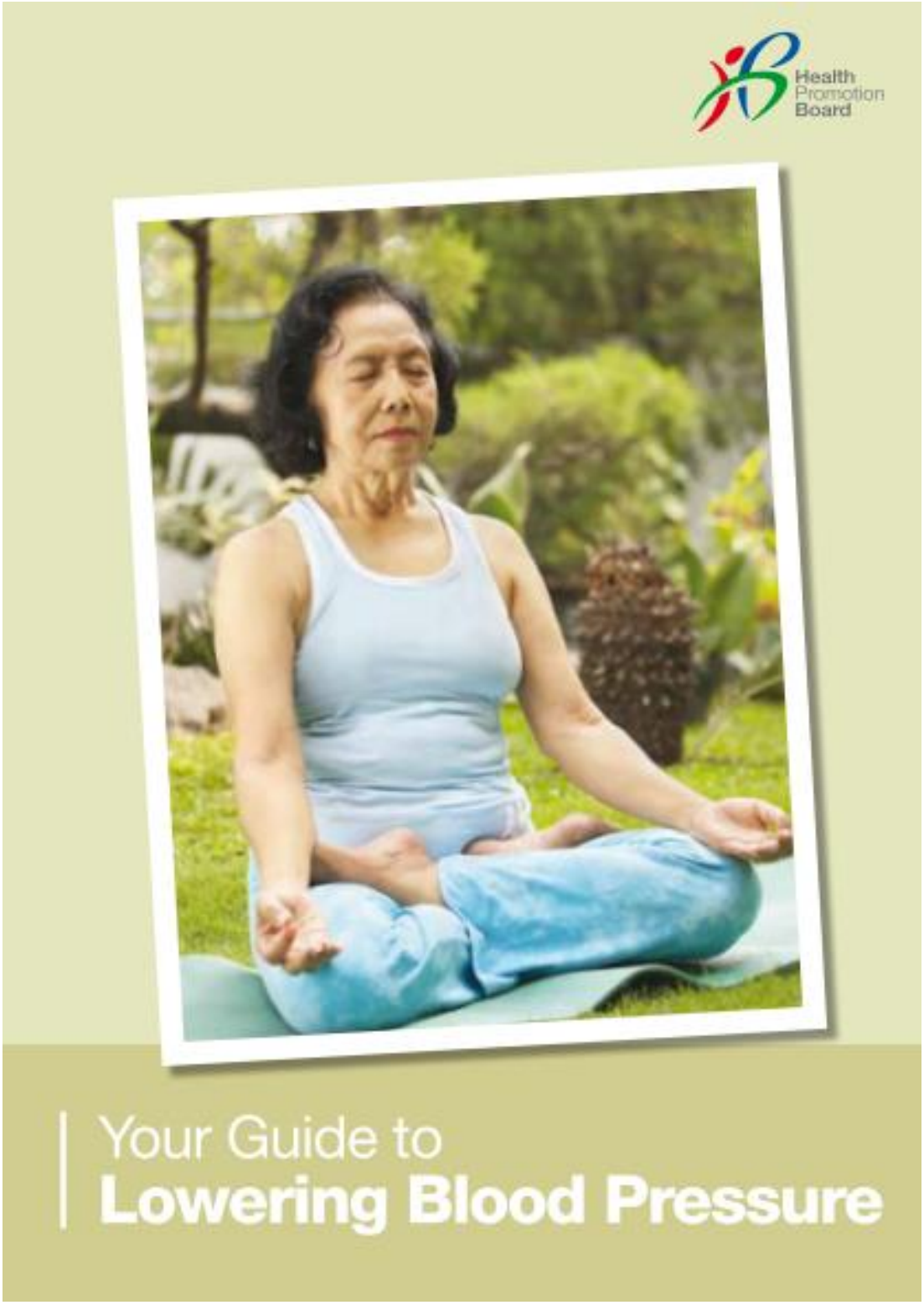
Lighten up on salt

Choose Healthier Choice Symbol (HCS) Products where possible.

Healthy eating does not need to be bland and boring. You can still enjoy the food you love with the right recipes. With this recipe book, you can cook up a delicious menu of good food for great health!

Let's get cooking!

APPENDIX K: HEALTH BOOKLET
(YOUR GUIDE TO LOWERING BLOOD PRESSURE)



My Plan to Prevent or Control High Blood Pressure

Check two or three things you will do. Add more things over time.

Add spice – not salt, to your life

- Season foods with herbs and spices like garlic, hot pepper, coriander, and onion instead of salt.
- Eat more fruits and vegetables instead of salty snacks.

Take heart. Try to:

- Lose weight if you are overweight.
- Eat smaller portions – do not go for a second serving.
- Get 30 to 60 minutes of moderate physical activity on most days.
- Limit alcohol.

If you have high blood pressure:

- Have your blood pressure checked every 3-6 months.
- Take your medicine as instructed by your doctor.

Commonly Asked Questions about High Blood Pressure

Q What are the symptoms of high blood pressure?

A High blood pressure alone usually does not cause any symptoms until complications like kidney damage develop. That is why it is important to go to your doctor for regular check-ups and have your blood pressure monitored.

Q Should I take medication for high blood pressure?

A Weight loss, exercise, and diet are important parts to controlling your blood pressure. However, some people do need medication. If you need medication, be sure to take it as prescribed. Never stop or change the dosage without consulting your doctor.

Q Can I stop taking blood pressure medication if my blood pressure is under control?

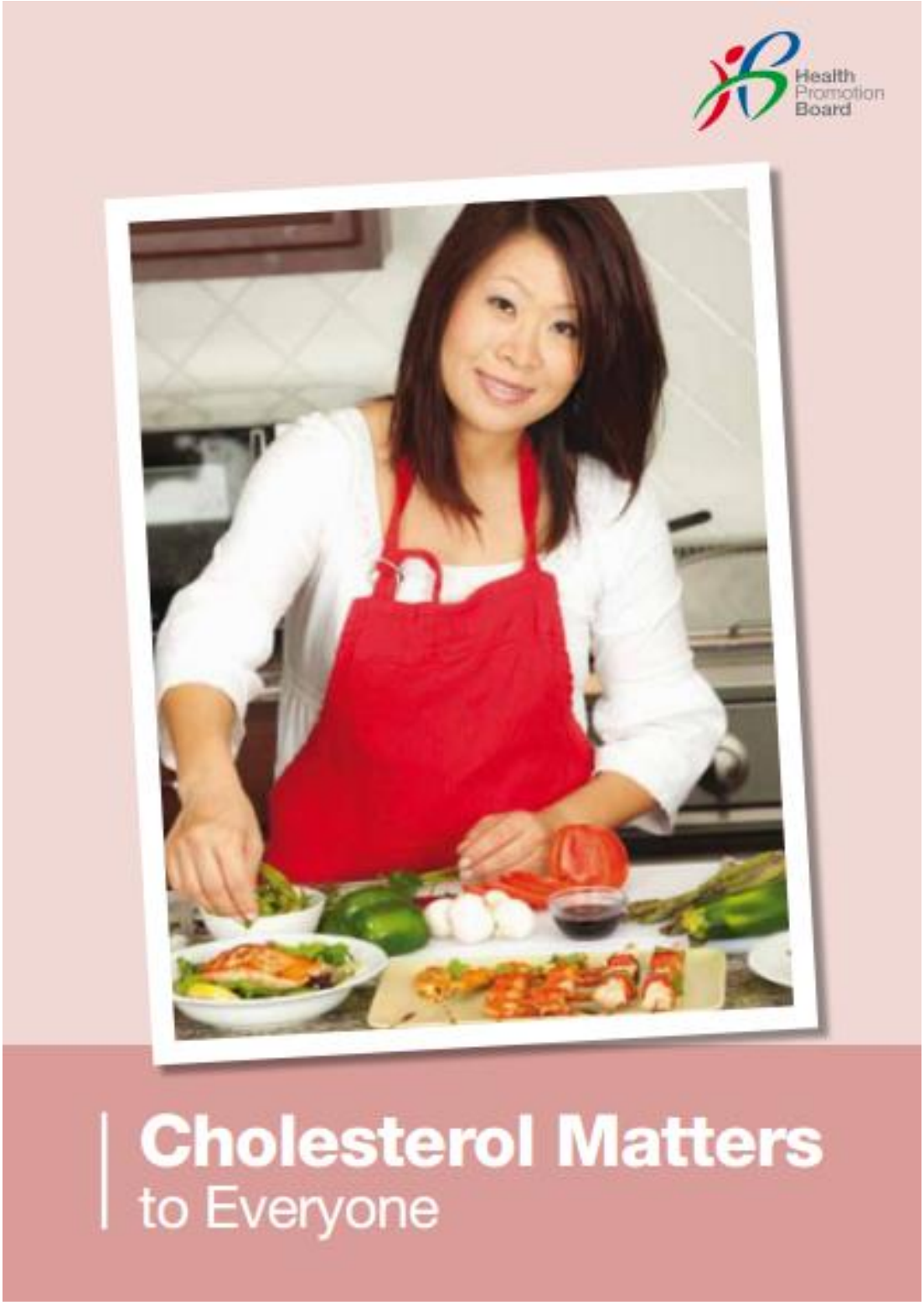
A No. Blood pressure treatment is usually life-long. Never stop or change the dose of your medication without consulting your doctor.

Always Take Your Medication as Prescribed

If you are taking blood pressure medication, it is important that you know the names of the medication and how to take them. Follow your doctor's directions precisely. Never skip days or take more or fewer pills than prescribed. Be sure to get refills before your current supply runs out.

If you experience side effects from your blood pressure medication, talk to your doctor immediately. Your dosage may need to be changed or you may need to switch to another medicine. You should always consult your doctor before you make any changes to your medication plan.

APPENDIX K: HEALTH BOOKLET
(CHOLESTEROL MATTERS TO EVERYONE)



10 Tips for Managing Your Cholesterol

Having too much cholesterol increases your risk of heart attacks and strokes. The good news is that you can manage your cholesterol levels through exercise, healthy eating, weight loss, and, if necessary, medication. Here are some tips for managing your cholesterol:

1. Maintain a healthy weight through exercise and a healthy diet.
2. Engage in moderate-intensity aerobic activity over 3 to 7 days and accumulate 150 minutes throughout the week. Each session should last at least 10 minutes. Examples of moderate-intensity aerobic activities include brisk-walking, recreational swimming and leisure cycling.

3. Engage in muscle-strengthening activities that work all major muscle groups (arms, abdomen, shoulders, chest, legs, hips and back) at least twice a week. Rest for at least 48 hours before your next session. Examples of muscle-strengthening activities include body weight resistance exercises, using resistance bands/ tubing and weight lifting.

4. Avoid foods that are high in trans fats, such as deep-fried food, pastries and cakes.

5. Use monounsaturated fats, like olive oil, instead of saturated fat (butter, ghee, and palm oil) when you cook.
6. Limit cholesterol-rich foods such as organ meats, shellfish, and eggs.
7. Eat more fibre, such as whole grain food, vegetables, fruit and beans.

8. Enjoy fish rich in Omega-3 fatty acids like sardine, longtail shad (terubok) and spanish mackerel (tenggiri papan) two to three times a week.
9. Ask your doctor or pharmacist for help to quit smoking or call QuitLine 1800-438-2000 – smokers who stop, see an improvement in their HDL levels.
10. Take medication as prescribed by your GP or family doctor to help lower your cholesterol.

APPENDIX K: HEALTH BOOKLET
(KEEPING MY BLOOD SUGAR LEVEL HEALTHY)

2. Keep a Healthy Diet

Did you know that keeping a healthy diet can improve your blood sugar levels? If you are overweight (BMI ≥ 23.0kg/m^2) or pre-diabetic, it is even more important for you to have a healthy diet.

Here are some general guidelines to eating healthily.

- **Eat a variety of food** from different food groups and within each food group.
- **Eat a balanced diet.** This means eating the recommended number of servings of food from the different food groups daily.
- **Eat in moderation.** This means eating the right amount of food, neither too much not too little.

If you have diabetes or a medical condition, you should consult a doctor or a dietitian.

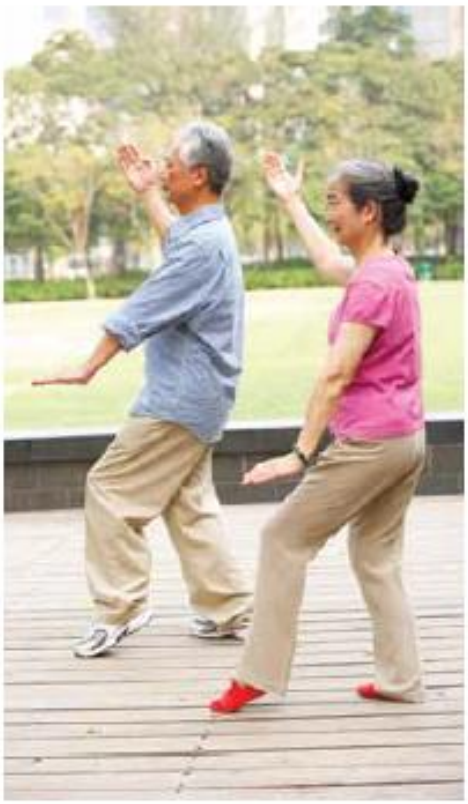
3. Stay Active

Staying active can help you lose weight, burn fat and improve your sugar control. When done regularly, it can prevent heart disease and stroke.

- Take up tai-chi or go for a swim with friends.
- Get off the bus one stop earlier.
- Take the stairs instead of the lift.
- Take a walk with your family after dinner.
- Keep active by doing housework.

If you do not exercise regularly, check with your doctor before starting on a physical activity programme. Get a friend or family member to do it with you. Make it fun!

Aim for 150 minutes of physical exercise a week; do at least 10 minutes each time for health benefits. It's easy!



APPENDIX K: ACCELEROMETER INSTRUCTIONS

Curtin University

Dear Participant
（亲爱的参与者）

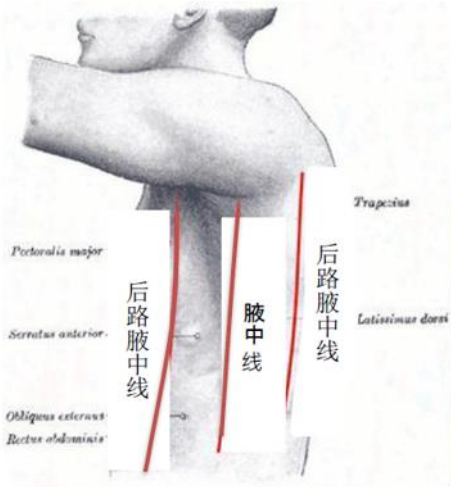
Enclosed you will find an accelerometer which is a device to measure your physical activity. Below you will find instructions for wearing this device.
(加速度计已被附上用来测量您的体力活动。以下是如何穿戴这个仪器的说明。)

The device – you don't need to turn it on; it will be recording data automatically. The flashing light will cease once data recording begins so don't worry if you notice it's not flashing.
(仪器 – 您不需要打开，它会自动记录数据。当数据记录开始时，闪烁的灯光就会停止，所以若发现灯光没有闪烁您不必担忧。)

Times to wear – please wear for 7 consecutive days during waking hours. It can be worn both during work hours and evenings/weekends. Please remove the device for showering and sleeping only.
(穿戴时间 – 请连续 7 日在醒着的时候穿戴。在工作和傍晚或周末时可以穿仪器。请只在洗澡和睡觉时摘下仪器.)

Time to return – once you have completed the 7 days please place the device in the envelope provided and return ASAP to the reception desk (unless alternative arrangements have been made). *Your program materials will be sent to you once you have returned your device.*
（归还时间 – 只要您完成了 7 天，请将仪器放在提供的信封并尽快归还至前线柜台（除非已有另作安排）. *您的活动资料将在您归还您的仪器后寄给您。*）

How to wear – Attach the device to the midaxillary line on the **right hip bone**. Please don't cut the band.
（这么穿戴 – 将仪器附带在右胯骨的腋中线。请不要剪断带子。）



If you have any questions please let me know.
(若您有任何问题请通知我。)

Kind regards
（亲切的问候）

Elaine Wong Yee Sing
Project Officer
（项目官员）

Tel | +65 81387834
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Email | yeesing.wong@student.curtin.edu.au
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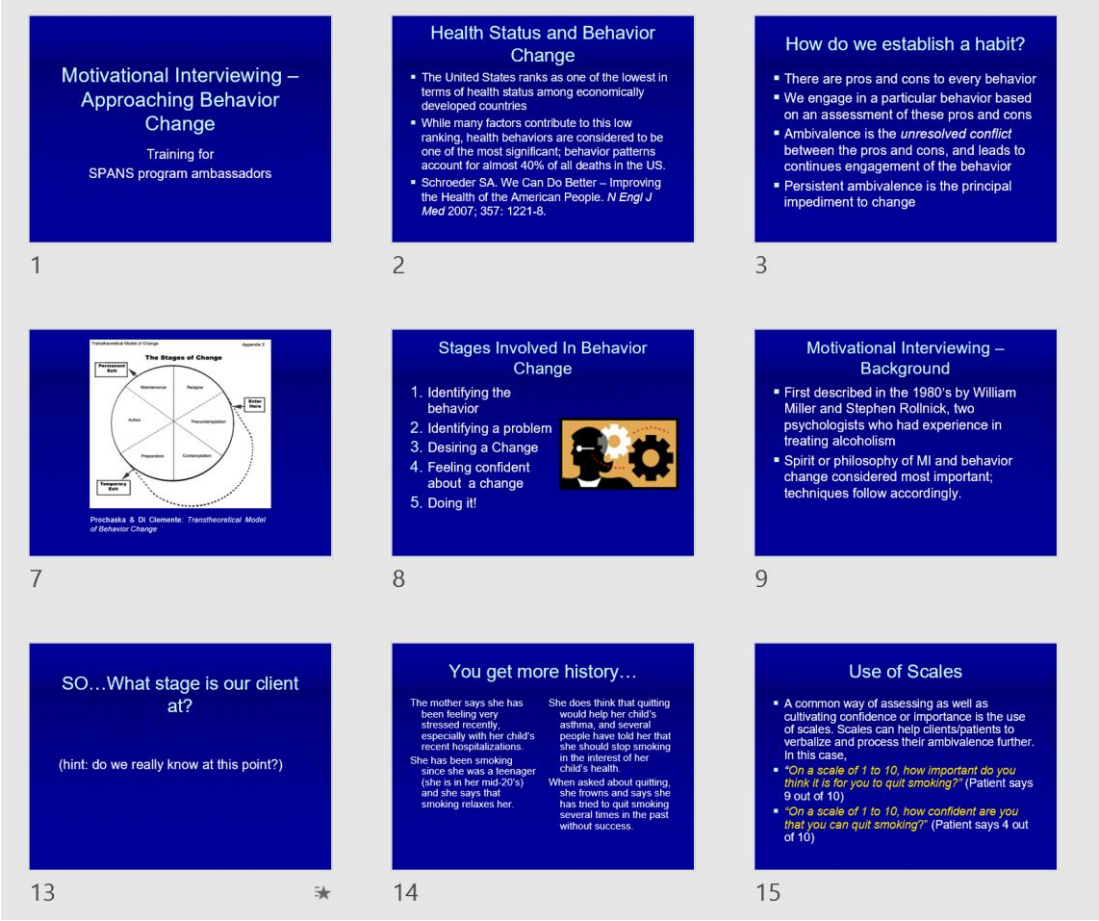
APPENDIX K: MOTIVATIONAL INTERVIEWING TRAINING RESOURCES



APPENDIX K: SAMPLE INCENTIVES

RECYCLING TOTE BAG, SPORTS TOWEL, MAGNETIC FRIDGE NOTE PAD AND SUPERMARKET VOUCHERS

APPENDIX L: MAPPING OF THEORY, MODEL AND MOTIVATIONAL INTERVIEWING

APPENDIX L: MAPPING OF SOCIAL COGNITIVE THEORY TO INFORM STRATEGIES AND METHODS

Social Cognitive Theory constructs	Strategies	Methods
Self-efficacy	• Identify barriers, goal-setting, monitor progress and mastery of health practices.	• Regular feedback on participants' progress in regular PA and healthy eating. • Encourage the practice of health-enhancing skills to achieve goals and health outcomes.
Observational Learning	• Observe culinary, shopping and PA demonstration. • Learn new skills from peer-aged mentors who act as positive role models.	• Program ambassadors demonstrate correct PA movements, cooking and shopping skills. • Participants observe and share PA and dietary experiences with their peers.
Positive Reinforcement	• Use direct and vicarious reinforcement during educational sessions.	• Provide regular encouragement and follow-up. • Monitor health goals, give support and feedback. • Reward participants with incentives.
Environment	• Build social rapport with participants in practising and adopting healthy lifestyle habits.	• Conduct face-to-face meetings and feedback sessions, follow-up calls and 'WhatsApp' messaging with the participants.
Self-control	• Provide resources for self-monitoring.	• Activity planner (in PA booklet and calendar) and accelerometers to set goals, record and monitor their PA and dietary goals. • Recipe and health booklets provide health tips and suggested activities.

Outcome Expectations	• Educate about the benefits of a nutritious diet and regular PA in improving health screening results. • Reinforce participants' expectations during educational sessions.	• Set healthy goals and provide resources at the initial meeting. • Conduct face-to-face sessions, follow-up calls and feedback to motivate them towards improving health outcomes.

PA: physical activity

APPENDIX L: MAPPING OF SOCIO-ECOLOGICAL MODEL TO INFORM STRATEGIES AND METHODS

Social-ecological model factors	Strategies	Methods
Individual	• Provide knowledge and skills training that motivate participants towards healthy behaviours.	• Draw on participants' experience to build upon new PA and dietary knowledge and skills. • Develop cumulative growth in their confidence and control to change behaviours.
Interpersonal	• Increase social networks to increase PA and healthier eating habits.	• Perform paired activities for them to interact with their peers and extend activities to their family, friends or colleagues.
Community	• Provide a socially supportive RC environment that facilitates PA and healthy eating.	Ensure that PA activities are conducted in safe environments that are culturally appropriate to promote a healthy lifestyle.
Organisational	• Develop strong rapport with RC managers to ensure smooth execution of intervention activities.	• Conduct face-to-face meetings, feedback and follow-up call with RC managers to gather issues, challenges and barriers.
Policy	• Conduct audits of RCs' facilities and activities to ensure their appropriateness and relevance for the participants.	• Involve participants and RC managers to identify motivators, barriers and suggestions to inform practice development.

PA: physical activity, RC: recreational centre

APPENDIX L: MAPPING OF MOTIVATIONAL INTERVIEWING TECHNIQUES TO INFORM STRATEGIES AND METHODS

Motivational interviewing techniques	Strategies	Methods
	• Train program ambassadors in MI techniques.	• Provide training resources, role-play practices and feedback on MI techniques.
	• Support participants to increase their intrinsic motivation to adopt healthy habits.	• Encourages participants to discuss their need for change and reasons for wanting to change when conducting dietary phone counselling sessions.
	• Assist participants in resolving ambivalence by supporting self-efficacy and self-reflection and provide personalised feedback.	• Identify thoughts, feelings and emotions that lead them to continue with unhealthy behaviours. • Develop new thinking patterns to change behaviours.

APPENDIX M: PRE- AND POST-TEST QUESTIONNAIRE

For Office Use

HEALTH SURVEY

PERSONAL DETAILS

	Code
1. What is your age? _____ years For questions 2 & 3 please only cross out only one box.	Q1 [ ]
2. What is your ethnicity? Chinese……. [1] Malay…….. [2] Indian …… [3] Other_____ [9]	Q2 [ ] _____
3. Which of the following best describes the highest level of education you have completed? Primary school or no education …… [1] High/secondary school …… [2] Diploma …… [3] University/tertiary education & above …… [4]	Q3 [ ]
4. Marital Status. Married…... [1] Widowed …… [2] Single …… [3] Divorced …… [4]	Q4 [ ]
5. Do you have any of the following? (cross out all that apply) Heart disease …… [1] Stroke …… [2] High blood pressure …..... [3] Diabetes …… [4] Cancer …….. [5] High cholesterol …..…… [6] Osteoporosis ……. [7] Arthritis ……. [8] Other: _____ [9]	Q5 [ ] _____
6. Are you taking any of the following medications? (cross out all that apply) Blood pressure medication (e.g. Ramipril)…… [1] Cholesterol medication (e.g. Lipitor) …… [2] Blood clotting/Anti-platelet medication (e.g. Aspirin) …….. [3] Beta-blockers (e.g. Cartrol/Cartia) …… [4] Others: _____ [9]	Q6 [ ] _____

7. Type of housing are you residing in.		Q7 [ ]
2 Room HDB Flat	1	
3 Room HDB Flat	2	
4 Room HDB Flat	3	
5 Room HDB Flat	4	
Others: _____	9	

Physical Activity

Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person. Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, household chores i.e. vacuuming, mopping, scrubbing floors and shopping for groceries etc. In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.	**Code**
8. **Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like carrying or lifting heavy loads, mopping or scrubbing floors for at least 10 minutes continuously?** Yes ..... [1] [2] No → *Skip to question 11*	Q8 [ ]
9. **In a typical week, on how many days do you do vigorous-intensity activities as part of your work?** _____ days per week	Q9 [ ]
10. **How much time do you spend doing vigorous-intensity activities at work on a typical day?** _____ hours per day _____ minutes per day	Q10 [ ]
11. **Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking, carrying light groceries, sweeping, washing windows for at least 10 minutes continuously?** Yes ..... [1] [2] No → *Skip to question 14*	Q11 [ ]

12. **In a typical week, on how many days do you do moderate-intensity activities as part of your work?** _____ days per week	Q12 [ ]
13. **How much time do you spend doing moderate-intensity activities at work on a typical day?** _____ hours per day _____ minutes per day	Q13 [ ]
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship.	
14. **Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?** Yes …….. [1] [2] No → *Skip to question 17*	Q14 [ ]
15. **In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?** _____ days per week	Q15 [ ]
16. **How much time do you spend walking or bicycling for travel on a typical day?** _____ hours per day _____ minutes per day	Q16 [ ]
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure).	
17. **Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like running, swimming or dancing such as quick step or salsa, aerobics, playing ball sports i.e. soccer, volleyball, basketball, netball or badminton for at least 10 minutes continuously?** **Yes** …….. [1] [2] **No → Skip to question 20**	Q17 [ ]

18. **In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?** _____ **days per week**	Q18 [ ]
19. **How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?** _____ **hours per day** _____ **minutes per day**	Q19 [ ]
20. **Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that causes a small increase in breathing or heart rate such as brisk walking, gardening, doing low-aerobic exercise, using hand weights, using resistance band, doing Qigong or Tai chi for at least 10 minutes continuously?** Yes …….. [1] [2] No → *Skip to question 23*	Q20 [ ]
21. **In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?** _____ **days per week**	Q21 [ ]
22. **How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?** _____ **hours per day** _____ **minutes per day**	Q22 [ ]
The following question is about sitting at work, lying on sofa at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, travelling in car, bus, train, reading or watching television, but do not include time spent sleeping.	
23. **How much time do you usually spend sitting or lying on a sofa on a typical day?** _____ **hours per day** _____ **minutes per day**	Q23 [ ]

Nutrition

The next questions ask about the fruits and vegetables that you usually eat. I have a nutrition poster here that shows you some examples of local fruits and vegetables. Each picture represents the size of a serving. As you answer these questions please think of a typical week in the last year.	Code
24. **In a typical week, on how many days do you eat fruit?** _____ **days per week** If Zero days, go to Q26.	Q24 [ ]
25. **How many servings of fruit do you eat on one of those days?** _____ **of servings**	Q25 [ ]
26. **In a typical week, on how many days do you eat vegetables?** _____ **days per week** If Zero days, go to Q28.	Q26 [ ]
27. **How many servings of vegetables do you eat on one of those days?** _____ **of servings**	Q27 [ ]
With the next questions, we would like to learn more about salt in your diet. Dietary salt includes ordinary table salt, unrefined salt such as sea salt, salty stock cubes and powders, and salty sauces such as soya sauce or fish sauce. The following questions are on adding salt to the food right before you eat it, on how food is prepared in your home, on eating processed foods that are high in salt such as luncheon meat, salted fish, Szechuan vegetable, preserved radish, preserved cai xin, salted egg, chinese sausage (lap cheong), fermented beancurd, and questions on controlling your salt intake. Please answer the questions even if you consider yourself to eat a diet low in salt.	
28. **How often do you add salt or a salty sauce such as soya sauce to your food right before you eat it or as you are eating it?** Always (6-7 times per week) ……. [1] Rarely (once per month)… [4] Often (2-5 times per week) ……. [2] Never …….. [5] Sometimes (2-4 [1 time per week] times per month) … [3]	Q28 [ ]

29. **How often is salt, salty seasoning or a salty sauce added in cooking or preparing foods in your household?** Always (6-7 times per week) ……. [1] Rarely (once per month)… [4] Often (2-5 times per week) ……. [2] Never ……. [5] Sometimes (2-4 [1 time per week] times per month) … [3]	Q29 [ ]
30. **How often do you eat processed food high in salt? By processed food high in salt, I mean foods that have been altered from their natural state, such as packaged salty snacks, canned salty food including pickles, Szechuan vegetables, and salty food prepared at a fast food restaurant, processed meat.** Always (6-7 times per week) ……. [1] Rarely (once per month)… [4] Often (2-5 times per week) ……. [2] Never ……. [5] Sometimes (2-4 [1 time per week] times per month) … [3]	Q30 [ ]
31. **How much salt or salty sauce do you think you consume?** Far too much (7 times per week)…. [1] Sometimes(1-3 times per week] [3] Too much (4-6 times per week)……. [2] Rarely (once per month)….. [4]	Q31 [ ]
32. **How important to you is lowering the salt in your diet?** Very important ……. [1] Not at all important …. [3] Somewhat important (50%)…. [2]	Q32 [ ]
33. **Do you think that too much salt or salty sauce in your diet could cause a health problem?** Yes …… [1] No …… [2]	Q33 [ ]
34. **Do you do any of the following on a regular basis to control your salt intake?**	
34a. Limit consumption of processed foods Yes …… [1] No …… [2]	Q34a [ ]
34b. Look at the salt or sodium content on food labels Yes …… [1] No …… [2]	Q34b [ ]

Lower in Sodium Healthier Choice Eat All Foods In Moderation **34c. Buy low salt/sodium alternatives** Yes ..... [1] No ..... [2]	Q34c [ ]
34d. Use spices other than salt when cooking Yes ..... [1] No ..... [2]	Q34d [ ]
34e. Avoid eating foods prepared outside of a home Yes ..... [1] No ..... [2]	Q34e [ ]
34f. Do other things specifically to control your salt intake Yes ..... [1] Other: [9] No ..... [2] *If Yes, go to 'Other'	Q34f [ ]
The next questions ask about the oil or fat that is most often used for meal preparation in your household, and about meals that you eat outside a home.	
35. **What type of oil or fat is most often used for meal preparation in your household?** Vegetable oil ..... [1] Non in particular/mixture..... [5] Lard or suet ..... [2] None used ..... [6] Butter or ghee..... [3] Margarine..... [4] Other: [9]	Q35 [ ]
36. **On average, how many meals per week do you eat that were not prepared at a home? By meal, I mean breakfast, lunch and dinner.** ____meals per week	Q36 [ ]

37. **How often do you eat high-fat foods like fried chicken wings, curry puff, ngoh hiang, spring roll, samosa, Indian rojak, goreng pisang, yutiao, ham chi peng and roti prata, etc?** Always (6-7 times per week) ……. [1] Often (2-5 times per week) ……. [2] Sometimes (2-4 [1 time per week] times per month) … [3] Rarely (once per month)… [4] Never ……. [5]	Q37 [ ]
38. **How often do you eat processed meats like luncheon meats, bak-kwa, chinese sausage, smoked duck, spiced pork cube, minced pork with bean paste, etc?** Always (6-7 times per week) ……. [1] Often (2-5 times per week) ……. [2] Sometimes (2-4 [1 time per week] times per month) … [3] Rarely (once per month)… [4] Never ……. [5]	Q38 [ ]
39. **What type of dairy products do you usually eat/drink?** Whole milk or full cream……. [1] Low fat……. [2] Non-fat or skim milk …….. [3] None ……. [4]	Q39 [ ]
40. **Do you remove skin from poultry and trim visible fat from meats?** Yes ……. [1] No ……. [2]	Q40 [ ]
41. **What type of bread or bread roll do you USUALLY eat?** White bread (ordinary/enriched).. [1] Wholemeal bread ……. [2] A mixture of white and wholemeal bread … [3] Do not eat bread or bread roll at all… [4] Others : [9]	Q41 [ ] _____
42. **What type of rice do you USUALLY eat?** White rice ……... [1] Brown or red rice ……. [2] Do not eat rice at all …… [3] Mixture of white & brown or red rice… [4] Others : [9]	Q42 [ ] _____

43. **What type of sweetening agent do you USUALLY add to tea, coffee or other beverages?** Sugar…… [1] Do not add any sweetening agent at all… [3] Artificial sweeteners e.g. NutraSweet/ Equal/Saccharin-based syrups …… [2] Others :. [9]	Q43 [ ]
44. **How often do you drink sweetened drinks? (e.g. soft drinks, fruit drinks, packet drinks, cordials, yoghurt-based drinks and cultured milk drinks, etc.)** _____ **days per week**	Q44 [ ]
45. **How often do you eat sweet desserts and snacks? (e.g. cakes, kuehs, jellies, candies, chocolates, cookies, ice-cream, etc.)** _____ **days per week**	Q45 [ ]

SF-8TM Health Survey

This survey asks for your views about your health. This information will help you keep track of how you feel and how well you are able to do your usual activities. Answer every question by selecting the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can. For each of the following questions, cross out a box that best describes your answer.	**Code**
46. **Overall, how would you rate your health during the past 4 weeks?** Excellent …….. [1] Fair ……..…….. [4] Very Good …… [2] Poor ……. [5] Good …… [3] Very Poor …….. [6]	Q46 [ ]
47. **During the past 4 weeks, how much did physical health problems limit your physical activities (such as walking or climbing stairs)?** Not at all …….. [1] Quite a lot ……. [4] Very little…..…… [2] Could not do physical activities … [5] Somewhat……. [3]	Q47 [ ]
48. **During the past 4 weeks, how much difficulty did you have doing your daily work, both at home and away from home, because of your physical health?** Not at all …….. [1] Quite a lot ……. [4] Very little…..…… [2] Could not do daily work …… [5] Somewhat……. [3]	Q48 [ ]

49. **How much bodily pain have you had during the past 4 weeks?** None ……. [1] Very mild …… [2] Mild …… [3] Moderate …….…….. [4] Severe ..…… [5] Very severe …….. [6]	Q49 [ ]
50. **During the past 4 weeks, how much energy did you have?** Very much …….. [1] Quite a lot…..…… [2] Some …..…… [3] A little …… [4] None …….…… [5]	Q50 [ ]
51. **During the past 4 weeks, how much did your physical health or emotional problems (such as feeling anxious, depressed or irritable) limit your usual social activities with family or friends?** Not at all …….. [1] Very little…..…… [2] Somewhat…… [3] Quite a lot …… [4] Could not do social activities… [5]	Q51 [ ]
52. **During the past 4 weeks, how much have you been bothered by emotional problems?** Not at all …….. [1] Slightly ……..…… [2] Moderately …..…… [3] Quite a lot …… [4] Extremely …… [5]	Q52 [ ]
53. **During the past 4 weeks, how much did personal or emotional problems keep you from doing your usual work, school or other daily activities?** Not at all …….. [1] Very little…..…… [2] Somewhat…… [3] Quite a lot …… [4] Could not do daily activities… [5]	Q53 [ ]

Thank you for answering the questions. We really appreciate your time and assistance.

Office Use only:

Interviewer Name_____

Measurements

Your Program Ambassador will conduct the following measurements:

Waist circumference (cm) (record to the nearest 0.5cm)	**Hip circumference** (cm) (record to the nearest 0.5cm)	**Waist Hip Ratio** (record to the nearest 0.5cm)
_____(cm)	_____(cm)	_____(cm)

BMI [Weight/Height^2]_____kg/m^2

Measurement: Wt _____kg
Ht_____m

Body fat percentage

Measurement :_____ %

Program ambassadors: Please check through the questionnaire to make sure the participant has answered all of the questions.

Name of Participant: _____

Home address: _____

Home phone no: _____ **Mobile no**: _____

APPENDIX N: INTERVIEW QUESTIONS FOR FOCUS GROUP DISCUSSION

Curtin University

FOCUS GROUP DISCUSSION

Introduce the complimentary program (pre-health screening and accelerometer followed by three nutrition talks, 12 fitness low impact aerobic classes for seniors, three sessions of dietary counselling, monthly dietary and fitness tips followed by post health screening and post accelerometer). There is no right or wrong answer. This discussion is to share between ourselves and not outside of this room.

Q1: WHAT or WHO may influence your eating and exercise habits?

Q2: What will make you OR why will you want to participate in nutrition and fitness program?

Q3: What would you like to have or see in a nutrition and fitness program? What will you like to get out of it?

Q4: What motivates you to exercise and eat well?

Q5: What are the barriers that prevent you from exercising and eating well?

Q6: What do you think of the materials we are giving out, i.e. booklets

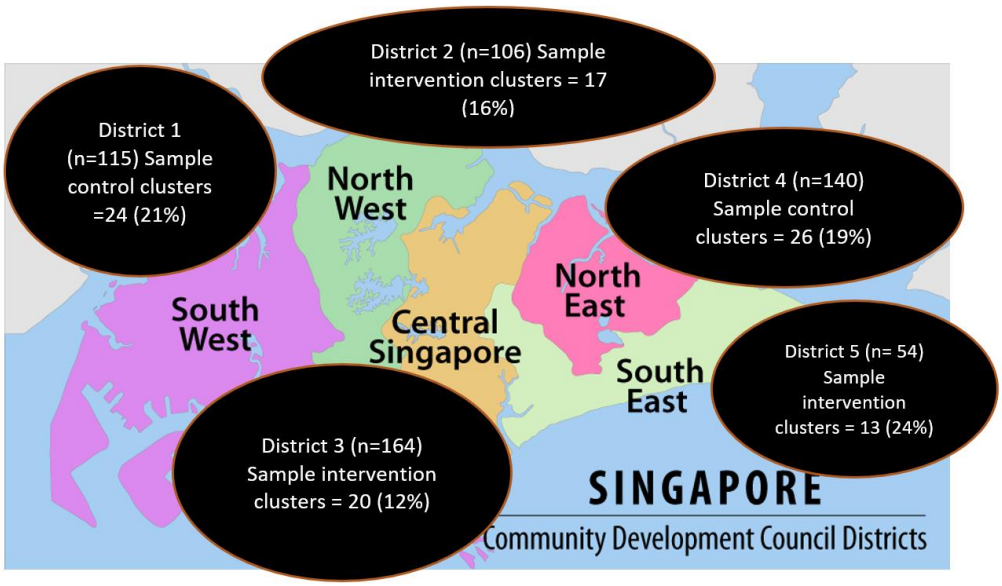
Q7: What makes you want to wear or not wear the accelerometer?

Q8: How do you think this program will benefit you? Or make you feel?

Q9: What incentives or rewards you will like to see in the program?

Q10: What and which aspects of your health will you like to change the most?

APPENDIX O: AUDIT STUDY SITES



Legend:
District 1 – South West (Control RC clusters)
District 2 – North West (Intervention RC clusters)
District 3 – Central Singapore (Intervention RC clusters)
District 4 – North East (Control RC clusters)
District 5 – South East (Intervention RC clusters)

Note: All of the five major districts vary in the number of residential centres (RCs). Thus, 12-24% of a subsample of audited RCs was randomly selected from the districts.

Subsamples of audited recreational centres

Districts	No. of RCs in district	No. of RCs audited
Intervention		
Central	164	20 (12%)
North West	106	17 (16%)
South East	54	13 (24%)
Control		
North East	140	26 (19%)
South West	115	24 (21%)
TOTAL	579	100 (17%)

APPENDIX P: AUDIT CHECKLIST

AUDIT CHECKLIST OF RECREATIONAL CENTRES IN SINGAPORE:

City code: _____

Geographical location: NW / SW / NE / SE / Central

A. Centre information

Complete in office before site visit, check website or contact centre.

1. Date _____

2. Contact name _____

3. Name of organization _____

B. Outside Positive Physical Activity and Nutrition Features

B1	> 1 grassy areas > 6 m x 6 m	No	Yes
B2	Presence of parks and plants (within 400 m)	No	Yes
B3	Bike racks	No	Yes
B4	Coffee corner with benches	No	Yes
B5	Vegetable / fruit / spice garden	No	Yes
B6	Healthy 'point of decision' prompts	No	Yes
B7	Vending machines that sells healthy food	No	Yes
C. Outside Hazards			
C1	Lack of footpaths to centre	No	Yes
C2	Obstructions on path to centre	No	Yes
C3	≤ 1 exterior well lighted light outside the centre	No	Yes

D. Outside Exercise Facilities

D1	Basketball / badminton courts	No	Yes
D2	Exercise / fitness stations	No	Yes
D3	Bike paths	No	Yes
E. Inside Exercise and Nutrition Facilities			
E1	Fitness gym / corner / space	No	Yes

E2	Weights / resistance equipments	No	Yes
E3	Presence of a kitchen	No	Yes
E4	Utensil / Stove / Wok / Induction cooker / Oven	No	Yes
E5	Washing basin for food preparation	No	Yes
E6	Availability of nutrition, physical activity, health booklets or healthy recipe handouts	No	Yes
F. Inside Social Facilities			
F1	Exergames / interactive video games	No	Yes
F2	Mind fitness / card games	No	Yes
F3	Open social lounge or living room area with TV	No	Yes
F4	Dining room	No	Yes
F5	Public computer (with internet access)	No	Yes
F6	Library	No	Yes
G. Nearby Services (< 400 m)			
G1	Supermarket / Wet markets	No	Yes
G2	Coffee shops / Food courts	No	Yes
G3	Convenient stores	No	Yes
G4	Gym / Community centres	No	Yes
G5	Pharmacy	No	Yes
G6	Physiotherapist clinic	No	Yes
G7	Medical / dental clinic	No	Yes
G8	Close proximity to bus stops and MRTs (Mass Rapid Transport)	No	Yes

H. Additional Site and Demographics Info

H1	Building land area (square feet) _____
H2	No. of elderly attending an activity per occasion (range)_____
H3	Age profile (Range)_____
H4	Gender distribution (Percentage) M_____% F _____%
H5	Percentage of independent elderly versus other patrons_____
H6	No. of organised exercise activities offered by the centre per month _____
H7	No. of organised mental wellness activities offered by the centre per month_____
H8	No. of organised nutrition related activities offered by the centre per month_____
H9	Has the centre been involved with any Health Promotion Board's initiative? _____ If yes, how many years? _____
H10	Any government funding to promote community activities for elderly? _____
H11	Any health screening conducted in the centre previously for the elderly? _____
H12	Would the centre be keen to participate in nutrition and physical programme for 6 months? Yes/ No Would the elderly co-pay for these programme? Yes/ No If yes, what is the amount that they would pay per month? i.e. $5 - $20 per month (Range)_____

APPENDIX Q: COMPONENTS OF INTERVENTION PROGRAM

APPENDIX Q: PHYSICAL ACTIVITY LESSON PLANS

Lesson 1

INTRO (5 mins)
Introduce my name
Name the type of class
Talk about the class structure
Reassure the first-timers just to follow through, and just march on the spot as a holding pattern if feeling out of breath, join us again when they are ready. Raise your hand and go to the side of the room if you feel unwell so that I can attend to you.
Organise the class, make sure the mats and water bottles are at the side and spread out their arms wide so that they don't hit their friends. Also made sure they signed the PAR-Q so that we can serve them better.

Section A: Warm-up
Learning curve Technique: Linear Progression (11 mins)

Exercise Type	Counts
A. March – Breathing A1. March	32
B. Step touch B1. Step touch with arms	
C. Easy walk (left) C1. Easy walk with arms (left)	
D. Easy walk (Right) D1. Easy walk with arms (Right)	
E. Touch Step rolling the shoulders E1. Touch Step with arms	
F. Grapevine F1. Grapevine with the arms	
G. Leg Curl G1. Leg Curl with arms	
H. Heel Raise H1. Heel Raise with arms	
Repeat all steps Holding pattern – March (Explain next part)	

Stretch and Joint Mobilisation (4 mins)

Exercise type	**Learning curve**	**Counts**
Calf Stretch -Static and Dynamic	Linear Progression	32
Hamstring Stretch -Static and Dynamic		
Hip Flexors Stretch -Dynamic		
Tricep Stretch front and back		
Hand Stretch out and up		
Quadricep Stretch		
Knee Rotation		
Ankle Rotation		
Ankle Point and Flex		

Quick water break if needed (1 min)

Section B: Main Cardio Section (15-17 mins)
Learning curve: Add-on

Exercise Type	Counts
A. March – Breathing A1. March – Forward and back	32
B. Step touch B1. Double step touch	
C. Easy walk (left) C1. Easy walk with point (left)	
D. Easy walk (Right) D1. Easy walk with point (Right)	
Repeat A1-D1	
E. Touch step E1. Touch step with side jab	
F. Grapevine F1. Grapevine arms to the head and clap	
G. Leg Curl G1. Leg Curl take in low	
H. Heel Raise with Arms H1. Heel Raise with a twist	
Repeat E1-H1	

Combine A1 to H1 → 32 counts → 16 counts
Repeat as practice if needed

Water break time (3 mins)

Revise A1-H1 → 32 counts

Section C: Chair aerobics -- Memory Game Exercise (10 mins)

Exercise type	**Learning curve**	**Counts**
1. L-shape hands	Number Association method and Add-on (with omission)	32
2. Peace sign		
3. Fist build		
4. Ah-go-go		
5. Peek-a-boo		
6. Peek-a-boo with feet out		
7. Hand wave		
8. Fish		
9. Limbs touch		
10. Shimmy		
Repeat 1 to 10	Recall	

Hands Relaxation

Exercise type	**Learning curve**	**Counts**
Shake out tension	Linear	32
Tricep Stretch and back		
Stretch hands out and up		
Breathing in and out		

Practice Dance steps and Chair Aerobics, explanation of correct technique if needed (Section B and C) -> 5 mins

Strength and Balance – (5 mins)

Exercise type	Learning curve	Counts
1. Seated/Standing Marching 2. Marching and Breathing 3. Squats with/without chair 4. Knee up the balance with or without support from chair 5. Balancing side to side with or without Chair 6. Leg extensions with or without the chair 7. Quadricep Stretch 8. Breathing in and out	Linear progression	32

Stretching (3 mins)

Exercise type	Learning curve	Counts
Calf Stretch	Linear Progression	32
Hamstring Stretch		
Hip Flexors Stretch		
Tricep Stretch		
Stretch Hands		

Breathing in and out first before Closing.

CLOSE (3 mins)

Congratulate the class for doing so well
Local (news): Inform them when is the next class
Offer advice: Drink lots of water stay hydrated, remember to exercise on their own. Happy to receive any feedback too
Smile: Remember to stay happy for the rest of the day because you have taken the time to do something good for your body
Exchange: Offer my name card. If participants are willing, we can exchange numbers for keeping in touch.

Lesson 2

INTRO (5 mins)
Introduce my name
Name the type of class
Talk about the class structure
Reassure the first-timers just to follow through, and just march on the spot as a holding pattern if feeling out of breath, join us again when they are ready. Raise your hand and go to the side of the room if you feel unwell so that I can attend to you.
Organise the class, make sure the mats and water bottles are at the side and spread out their arms wide so that they don't hit their friends. Also made sure they signed the PAR-Q so that we can serve them better.

Section A: Warm-up
Learning curve Technique: Linear Progression (10 mins)

Exercise Type	Counts
A. March – Breathing A1. March	32
B. Step touch B1. Step touch with arms	
C. Touch Step Rolling the shoulders C1. Touch Step with arms	
D. Grapevine D1. Grapevine with the arms	
E. Leg Curl E1. Leg Curl with arms	
F. Heel Raise F1. Heel Raise with arms	
G. Box Step (to the right) G1. Box Step (with arms)	
H. Box Step (to the left) H1. Box Step (with arms)	

Stretch and Joint Mobilisation

Exercise type	**Learning curve**	**Counts**
Calf Stretch -Static and Dynamic	Linear Progression	32
Hamstring Stretch -Static and Dynamic		
Hip Flexors Stretch -Dynamic		
Tricep Stretch front and back		
Hand Stretch out and up		
Quadricep Stretch		
Knee Rotation		
Ankle Rotation		
Ankle Stretch and Flex		

Quick water break if needed (1 min)

Section B: Main Cardio Section (15 mins)
Learning curve: Add-on

Exercise Type	Counts
A. March – Breathing A1. March – Forward and back	32
B. Step touch B1. Step Touch Arms out and in B2. Step touch arms out and in sideways	
C. Touch Step C1. Touch Step hands reach out	
D. Touch Step D1. Touch Step hands reach up	
Repeat	
E. Grapevine E1. Grapevine and pose	
F. Leg Curl F1. Leg Curl take it low	
G. Heel Raise with Arms G1. Heel Raise with a twist	
H. Boxstep (right) + with arms H1. Boxstep (left) + with arms	
Repeat	

Combine A – H together → 32 counts + 16 counts (Repeat 2-3 times as needed)

Water break → 3 mins

Revise A1-H1 → 32 counts (4 mins)

Section C: Salsa and Dance (8 mins)
Learning Curve: Add On

Dance	**Counts**
A. Step front and back (left) A1. Step front and back with cha cha B. Step Front and back (right) B1. Step front and back with cha cha C. Step to the side cha cha C1. Step to the side cha-cha with arms D. Step Behind D1. Step Behind with arm movements **Repeat A1-D1 a few times as needed**	32

Section D: Strength and Balance (8 mins)

Exercise type	Learning curve	Counts
A. Squats (slow) A1. Squats (single) A2. Squats (Pulse)	Linear progression with Marching breaks in between	16-32
B. Lunge forward (left) B1. Lunge forward (right) B2. Lunge forward (left and right) B3. Lunge forward and pulse (left) B4. Lunge forward and pulse (right)		
C. Legs Side to Side		
D. Hip Extension		
March – Breathing in and Out		

Stretching (3 mins)

Exercise type	Learning curve	Counts
Quadricep Stretch	Linear Progression	32
Calf Stretch		
Hamstring Stretch		
Hip Flexors Stretch		
Tricep Stretch		
Breathing in and out		

CLOSE (3 mins)

Congratulate the class for doing so well
Local (news): Inform them when is the next class
Offer advice: Drink lots of water stay hydrated, remember to exercise on their own. Happy to receive any feedback too
Smile: Remember to stay happy for the rest of the day because you have taken the time to do something good for your body
Exchange: Offer my name card. If participants are willing, we can exchange numbers for keeping in touch.

Lesson 3

INTRO (5 mins)
Introduce my name
Name the type of class
Talk about the class structure
Reassure the first-timers to just follow through, and just march on the spot as a holding pattern if feeling out of breath, join us again when they are ready. Raise your hand and go to the side of the room if you feel unwell so that I can attend to you.
Organise the class, make sure the mats and water bottles are at the side and spread out their arms wide so that they don't hit their friends. Also made sure they signed the PAR-Q so that we can serve them better.

Section A: Warm-up
Learning curve Technique: Linear Progression (10 mins)

Exercise Type	Counts
A. March – Breathing A1. March	32
B. Step touch B1. Step touch with arms up	
C. Touch Step Rolling the shoulders forward C1. Touch Step Rolling the shoulders back	
D. Grapevine D1. Grapevine with the arms and clap	
E. Leg Curl hands on hip E1. Leg Curl with arms up	
F. Heel Raise F1. Heel Raise with arms	
G. Easy Walk Right G1. Easy Walk Right (with arms)	
H. Easy Walk Left H1. Easy Walk Left (with arms)	

Stretch and Joint Mobilisation (3-4 mins)

Exercise type	**Learning curve**	**Counts**
Calf Stretch -Static and Dynamic	Linear Progression	32
Hamstring Stretch -Static and Dynamic		
Hip Flexors Stretch -Dynamic		
Tricep Stretch front and back		
Hand Stretch out and up		
Quadricep Stretch		
Knee Rotation		
Ankle Rotation		
Ankle Stretch and Flex		

Quick water break if needed (1 min)

Section B: Main Cardio Section (17 mins)
Learning curve: Add-on

Exercise Type	Counts
A. March – Breathing A1. March – Forward, March on the spot, and back, march on the spot	32
B. Step touch B1. Step Touch Arms out and in B2. Step touch arms out and in sideways	
C. Touch Step C1. Touch Step hands reach out	
D. Touch Step D1. Touch Step hands reach up	
Repeat A1+B2+C1+D1	
E. Grapevine E1. Grapevine and pose	
F. Leg Curl F1. Leg Curl take it low	
G. Heel Raise with Arms G1. Heel Raise with twist	
H. Boxstep (right) + with arms H1. Boxstep (left) + with arms	
Repeat E1+F1+G1+H+H1	

Combine A1 – H1 together → 32 counts + 16 counts (Repeat 2-3 times as needed)

Water break → 5 mins

Revise A1-H1 → 32 counts

Section C: Kickboxing (8 mins)
Learning Curve: Add On

Kickboxing	**Counts**
A.March A1. March Breathing in and out to the guard position B. Jab Slow B1. Jab Fast C. Hook Slow C1. Hook Fast D. Upper cut Slow D1. Upper Cut Fast **Repeat A1-D1 -> 2 times -> 32 counts each, followed by 16 counts**	32

Section D: Strength and Balance (6 mins)

Exercise type	Learning curve	Counts
A. Squats (slow) A1. Squats (single) A2. Squats (Pulse)	Linear progression with Marching breaks in between	16-32
B. Lunge forward (left) B1. Lunge forward (right) B2. Lunge forward (left and right) B3. Lunge forward and pulse (left) B4. Lunge forward and pulse (right)		
C. Legs Side to Side		
D. Hip Extension		
E. Knee Raises		

Stretching (3 mins)

Exercise type	Learning curve	Counts
Quadricep Stretch	Linear Progression	32
Calf Stretch		
Hamstring Stretch		
Hip Flexors Stretch		
Tricep Stretch		
Breathing in and out		

CLOSE (1 min)

Congratulate the class for doing so well
Local (news): Inform them when is the next class
Offer advice: Drink lots of water stay hydrated, remember to exercise on their own. Happy to receive any feedback too
Smile: Remember to stay happy for the rest of the day because you have taken the time to do something good for your body
Exchange: Offer my name card. If participants is willing, we can exchange numbers to keep in touch.

APPENDIX Q: DETAILS OF PHYSICAL ACTIVITY CLASSES

12 PA classes	Program details
PA class 1 [Week 2]	**Introduction to Fitness** • Distribute resources. • Explain benefits, barriers and motivators. • Remind to hydrate and follow safety rules during the class. • Encourage walking outside classes. • Set short- and long-term goals. **Activities (PA lesson plan 1)** • Warm-up (easy walk) • Low-intensity aerobic workout (step touch) • Muscle strengthening (squat) • Cool-down stretches (calf)
PA class 2 [Week 4]	**How Fit Are You?** • Introduce physical activity guidelines and teach taking of pulse rate. • Compare pulse rate with the fitness chart to determine their fitness levels. • Review previous goals and consider setting a new goal with a partner. **Activities (PA lesson plan 2)** • Warm-up (march) • Low-intensity aerobic workout (box step) • Muscle strengthening (lunge) • Cool-down stretches (hip flexor)
PA class 3 [Week 6]	**The F.I.T.T Principle** • Explain the recommended principles of frequency, intensity, time and type of physical activity (FITT). • Ask them to inform a partner if they are currently meeting the above FITT principles. • Review previous goals and consider setting new goal with a partner. **Activities (PA plan lesson 3)** • Warm-up (touch step and roll shoulder) • Low-intensity aerobic workout (step cha cha) • Muscle strengthening (leg raise side to side) • Cool-down stretches (tricep)

PA class 4 [Week 8]	**Feel Good with Some Activity** • Explore reasons for not being active and ways to overcome this. • Ask them to discuss barriers and how they might overcome these. • Review previous goals and consider setting a new goal with a partner. **Activities (PA plan lesson 4)** • Warm-up (heel raise with arm) • Low-intensity aerobic workout (kickbox) • Muscle strengthening (side lunge) • Cool-down stretches (ankle)
PA class 5 [Week 10]	**Know Your Muscles** • Explain the function of different muscle groups and exercises to tone muscles. • Ask them to discuss with a partner muscle groups they use and how they do it. • Review previous goal and consider setting a new goal with a partner. **Activities (PA plan lesson 5)** • Warm-up (touch step, reach out) • Low-intensity aerobic workout (hook) • Muscle strengthening (knee raise) • Cool-down stretches (tricep)
PA class 6 [Week 12]	**Take Care of Your Bones and Joints** • Explain major bones and joints and their relation to movement. • During the class, test and recap the bones and joints and what movements they produce. • Review previous goals and consider setting a new goal with a partner. **Activities (PA plan lesson 6)** • Warm-up (lift step with arm) • Moderate-intensity aerobic workout (uppercut) • Muscle strengthening (lunge left and right) • Cool-down stretches (gluteal)
PA class 7 [Week 14]	**Physical Activity and Ageing** • Explain age-related changes in physical fitness and ways to address this. • Ask them to think about their physical activity, what they would like to change and how this could be achieved • Review previous goals and consider setting a new goal with a partner.

Activities (PA plan lesson 7)

- Warm-up (V step and arm)
- Moderate-intensity aerobic workout (touch step, hands reach out)
- Muscle strengthening (hip extension)
- Cool-down stretches (hand stretch)

PA class 8

[Week 16]

Exercise is Medicine!

- Emphasise the role of regular PA in the prevention and management of chronic diseases.
- Ask them to share any experience of how PA benefits someone they know with a chronic condition.
- Review the previous goals and set a new goal with a partner.

Activities (PA plan lesson 8)

- Warm-up (gallop with arm)
- Moderate-intensity aerobic workout (step mambo)
- Muscle strengthening (lunge and squat)
- Cool-down stretches (knee rotation)

PA class 9

[Week 18]

Get Ready for Physical Activity

- Explain common injuries and provide prevention tips.
- Ask them to think of an injury they want to avoid and how they can prevent it.
- Review the previous goals and set a new goal with a partner.

Activities (PA plan lesson 9)

- Warm-up (swim with shoulder)
- Moderate-intensity aerobic workout (wide legs and hip roll)
- Muscle strengthening (knee raise)
- Cool-down stretches (quadricep)

PA class 10

[Week 20]

Measure Your Fitness

- Demonstrate simple ways to assess upper, lower body strength and flexibility.
- Ask them to pair up with a partner and assess each other's flexibility (sit and reach test).
- Review the previous goals and consider setting a new goal with a partner.

Activities (PA plan lesson 10)

- Warm-up (kicks with arm)
- Moderate-intensity aerobic workout (sidekick)
- Muscle strengthening (side squat)
- Cool-down stretches (arms circle forward and back)

PA class 11 [Week 22]	**Guide to An Active Lifestyle** • Inform them of online health hub where they can get access to more fitness resources to keep active and healthy. • Ask them to think of other useful resources that they use and apply in their daily lives. • Review previous goals and consider setting a new goal with a partner. **Activities (PA plan lesson 11)** • Warm-up (twist with arm flex) • Moderate-intensity aerobic workout (hip shake) • Muscle strengthening (lunge forward) • Cool-down stretches (ankle point and flex)
PA class 12 [Week 24]	**Keep the Physical Activity Going!** • Provide them with ways that they can make achieve an active lifestyle. • Ask them to share what has motivated them for the past few weeks and how they can sustain their fitness levels. • Review the previous goals and set a new goal with a partner. **Activities (PA plan lesson 12)** • Warm-up (march with feet wide) • Moderate-intensity aerobic workout (K-pop hip sway) • Muscle strengthening (knee raise and hold) • Cool-down stretches (rolling shoulder)

PA: physical activity

APPENDIX Q: DETAILS OF NUTRITION WORKSHOPS, DIETARY COUNSELLING SESSIONS, PHONE TEXTS AND CALLS

Three nutrition workshops	Program details	Resources and activities
	Details of Nutrition Workshops	
Workshop 1 [Week 1]	**Eat Well, Shop Smart** • Distribute nutrition resources and introduce dietary guidelines. • Benefits, barriers and motivators to healthy eating. • 'My Healthy Plate' guidelines. • Look for Healthier Choice symbols. • Record dietary patterns for a typical day. • Establish short- and long-term dietary goals.	**Resources** *'Recipes for Healthy Ageing' nutrition guide* **Activities** • What Is In Your Plate? • Read your label!
Workshop 2 [Week 12]	**Cook and Dine Wise** • Spot healthier ingredients. • Provide healthy cooking tips. • Swap to lower-calorie dishes when eating out. • Explain dietary approaches to decrease the risk of hypertension. • Review workshop one's goal and consider setting new goals.	**Resources** • *'Recipes for Healthy Ageing' booklet* • *'Your Guide to Lowering Blood Pressure' booklet* **Activities** • Food calories ranking game • Guess 'What Is Cooking?' (herbs and spices)
Workshop 3 [Week 24]	**Take Charge of Your Health** • Explain the importance of managing high cholesterol and blood sugar levels. • Inform of ways to reduce low-density lipoprotein-cholesterol and increase high-density lipoprotein-cholesterol levels. • Brainstorm ways to maintain healthy cholesterol and blood sugar levels. • Review workshop two's goal and consider setting new goals.	**Resources** • *'Cholesterol Matters To Everyone' booklet* • *'Tips To Better Health Keeping My Blood Sugar Levels' booklet* **Activities** • Identify low to high food sources of cholesterol. • Match teaspoons of fat and sugar to photos of local dishes and beverages.

	Details of Dietary Counselling	
(45 minutes – once every two months) [Week 4, 12, 20]	**Change for A Healthier You!** • Review of dietary goals. • Replace negative thoughts with positive and more useful thoughts. • Identify social support to overcome relapse. • Emphasise intrinsic and extrinsic motivators to sustain health behaviours.	**Resources** • Recycling grocery bag with '*Healthy Lifestyle'* slogans. • Fridge magnet and writing pad with '*Eat More Fruit and Vegetables*' slogan. • Sports towel with '*Warm Up Before PA*' slogan. **Activities** • Role-play using MI techniques • Goal reflection and feedback to resolve ambivalence.
	Details of monthly texting and follow-up calls	
PA and nutrition phone text messages and ca (once per month) [Week 4 - 24]	**Healthy Thoughts** • Monthly follow-up text and calls on goals, feedback and enquiries via a "WhatsApp" group platform.	**Activities** • Answer questions, respond to feedback and give comments using MI techniques. • Reinforce the message of staying fit and eating smart.

MI: Motivational Interviewing, PA: physical activity

APPENDIX R: DATA MANAGEMENT PLAN

Curtin University

Research Data Management Plan

A physical activity and nutrition intervention for Singaporean women aged 50-69: A community based randomised controlled trial

Supervisor	Jonine Jancey
Data Management Plan Edited by	Yee-Sing Wong
Modified Date	18/07/2016
Data Management Plan ID	JANCEJ-HS01588
Faculty	Health Sciences

1 Research Project Details

1.1 Research project title

A physical activity and nutrition intervention for Singaporean women aged 50-69: A community based randomised controlled trial

1.2 Research project summary

SUMMARY:

Singapore has a rapidly aging population, where the majority of older women, are physically inactive and have unhealthy dietary habits, placing them at 'high risk' of non-communicable diseases. This 6-month community-based cluster randomised controlled trial (RCT) will involve the development, implementation and evaluation of a physical activity and nutrition program for community dwelling Singaporean women, who currently attend recreational centres (RCs) in their local neighbourhood. The intervention will include dietary education and counselling sessions, physical activity classes, and telephone contact by program ambassadors. Social Cognitive Theory with Motivational Interviewing will inform the development of strategies to support health behaviour change. Sixty recreational centres located in Singapore will be randomly selected from five major geographical districts and randomly allocated to the intervention (n=30) or control (n=30) cluster. A sample of 600 (intervention n=300; control n=300) women aged 50-69 years will then be recruited from these RCs. It is hypothesised that by the end of the intervention, the intervention group participants (n = 300) compared to the control group (n = 300), will show significant improvements in the following variables: lipid profile, body mass index, physical activity and dietary behaviour, and mental and physical health. Data will be collected over two time points and analysed with mixed regression modelling. This study will evaluate the impact of a community based intervention in RCs on improvements in physical activity and nutrition behaviours, mental and physical health, anthropometry, and lipid profiles of Singaporean women.

CONTEXT:

Singapore is a densely populated city with 5.5 million residents, comprising an ethnically diverse population of Chinese (74%), Malay (13%), and Indians (9%) [1], of which the proportion of dependant older adults is growing, representing a challenge for the government health sectors [2]. The Ministry of Health is responsible for raising health awareness, and ensuring the accessibility of health services provided to the local residents [3]. The Health Promotion Board was established in 2001 as a statutory board under the Ministry of Health, tasked with the vision of building "a nation of healthy people". As a key partner of national health promotion and disease prevention programmes, Health Promotion Board spearheads health education programmes and creates a 'health-supportive' environment in Singapore to try to address the growing prevalence of non-communicable disease (NCD) [4]. However, similar to other developed nations, unhealthy lifestyle practices among Singaporean older adults, such as the high consumption of readily available low-nutrient, energy dense meals and physical inactivity, continue to contribute to a high occurrence of NCDs.

APPROACHES:

Theoretical perspective underpinning this study is the Social Cognitive Theory (SCT), which identifies the interaction of the individual with the social and physical environment, and how this interaction influences health behaviours [39]. Understanding these interactions can assist in the design of an intervention to better promote and support positive behaviour change [40]. SCT specifies a set of psychosocial constructs that include self-efficacy, outcome expectations (cognitive influences); observational learning and social support (environmental influences); as well as goal-setting and reinforcement (behavioural influences) [40]. A key construct of SCT is self-efficacy, which is behaviour specific [41]. Strategies to support the development of behaviour change will include: coaching on benefits of healthful eating combined with regular PA (self-

efficacy); small incremental steps towards improving their health outcomes (outcome expectations): sharing of dietary and PA experiences with other participants in groups (observation learning); while the program ambassadors will encourage them to adopt health promoting habits (social support); and to practice their new skills (skill development).Their personalised dietary and PA goals will be monitored (goal setting) and they will be provided with regular feedback (positive reinforcement).

METHODOLOGY:

Research design

A 6-month community based PA and nutrition intervention cluster RCT suited to the Singaporean context will be implemented and then evaluated over two time points (baseline and 6 months). Participants

Sixty recreational centres located in Singapore will be randomly selected from five major geographical districts within Singapore and randomly allocated to the intervention (n=30) or control (n=30) cluster. The five major districts in Singapore, as shown in Appendix 3, will be divided into the intervention clusters (districts: 2-North West, 3-Central, and 5-South East) and the control clusters (districts: 1–South West, 4-North East). A minimum of a 4 km radius between all selected RCs to avoid risk of contamination. A sample of 600 (intervention n=300; controls n=300) women aged 50-69 years will then be recruited from these 60 RCs.

Procedure

Recruitment of participants
Program recruitment flyers will be placed on the RCs bulletin boards and promoted by the RC management. RC managers will provide the program ambassadors with the contact numbers of the interested participants. Potential participants will then be telephoned to explain the purpose of the study and to determine their eligibility based on the selection criteria. Selection criteria are: a) aged 50-69 years; b) achieve less than 150 minutes of moderate intensity physical activity per week; c) not have any medical condition that prohibit involvement in PA programme; d) not following a special or modified diet; and e) not participating in any nutrition and PA research.

After the initial telephone screening, eligible participants will be invited to participate in the study, informed of their rights and confidentiality, and a pre-screening date at a central RC location. The baseline data collection will be collected face-to-face by a program ambassador. At this initial meeting the accelerometer will be fitted and its management explained.

The wait-listed control clusters will only undergo pre and post data collection and will not receive any form of intervention except for an incentive of health products to demonstrate our appreciation for their time. After collection of their post health screening data, they will be given the health resources.

EXPECTED OUTCOME:

Shaping healthy lifestyle habits has been strongly linked to a reduction in NCDs [38]. Given the multiplicity of less than optimal dietary habits and high levels of physical inactivity among Singaporean women, it is imperative to develop appropriate lifestyle interventions at RCs to enhance both their physical and nutritional knowledge, as well as provide them with the opportunity to develop skills to support behaviour change. Since the proposed study is the first PA and nutrition cluster RCT conducted in Singapore for older women at their RCs, it acts as a baseline to determine the impact of this intervention on their health behaviours and to support optimal healthy aging outcomes. Moreover, findings from this study may provide insights and recommendations for policy makers and key stakeholders to develop, modify or create new healthy living RCs with supportive environments in future HDB premises.

Note: REFERENCES will be provided when requested.

1.3 Keywords
nutrition and physical activity intervention, older women, recreational-centre based, randomised controlled trial, health promotion, chronic health disease prevention, community, Singapore

2 Research Project Data Details

2.1 Research project data summary

Source of data / brief description of content matter:

a) Health screening data

Health screening results i.e. blood pressure readings, blood glucose levels, Body Mass Index (BMI), weight, body fat percentage, Waist Hip Ratio (WHR), lipid profile (cholesterol and triglyceride) would be conducted pre and post intervention

to assess any improvement after intervention.

b) Measurement instruments

- Self-reported physical activity behaviour will be obtained through the administration of a GPAQ, a validated and reliable instrument [48].
- Self-reported dietary eating habits will be assessed through a STEPS dietary behaviour questionnaire developed by WHO [61].
- Self-reported health related quality of life will be acquired through the Short Form 8 questionnaire [62, 63].
- Demographic data include age, ethnicity, education, marital status, existing medical conditions, type of medications, employment status, and type of residential dwelling will be collected by trained program ambassador.

c) Assessment of health related resources involve examining various characteristics of current RCs using a modified version of the 'Audit of Physical Activity Resources (APARS) [64]. This checklist will be conducted by program ambassadors at 100 randomly selected RCs to examine the level of resources that are currently existing in RCs.

d)Field notebooks for documentation of observations and findings

The nutritionists/dietitians including program ambassadors would be recording ways in how, what or which aspects of the research could be improve and any interesting findings throughout the research period.

e)Digital recording of focus groups for process evaluation and exit interview

Focus group discussions (12 women per focus group) will be randomly selected from the other clusters not selected in the research study. Process evaluation will be undertaken throughout the intervention program to determine reach (attendance); fidelity (quality of program and resources), together with recruitment dose delivered and received (satisfaction). Exit interviews will be undertaken with program-completers (n=12) and non-completers (n=12).

Overview of the data analysis method:

- Quantitative analysis After data collection, subgroups of interest will be examined and compared via the Statistical Package for the Social Science (SPSS) version 23 or STATA version 14. Descriptive and summary statistics will be used to quantify participants' characteristics and outcome variables. Multi-variate mixed regression analyses will be used to confirm the effects of the proposed health intervention, taking into account the repeated measures (at two time points) and the clustering of the observations.

- Qualitative Analysis All qualitative data will be transcribed within two weeks of interviewing. At least 10% of all transcribed data will be randomly selected and reviewed for each transcription. Transcribed data will be coded and common themes or categories created. Data will be collated, presented thematically and supported by direct quotes from participants. Data management of full transcripts and other text will be facilitated by the NVIVO software package. Participants will not be identified in any transcription.

Data ownership

As a co-funder for this research, Curtin University owns the rights to the data study results.

Note: REFERENCES will be provided when requested.

2.2 Will the data be identifiable

- Re-identifiable — identifiers have been removed and replaced by a code, but it is possible to re-identify an individual

2.3 Will data, including biospecimens, be sent overseas?

No

2.4 Data organisation and structure

Naming convention / directory structures and folders:

1.Audit checklist of Recreational Centres (RC) in Singapore Soft / Hard copies [Audit Checklist of RC*SW1*Updated 15th

Jan_2017.xls]

2.Pre and Post questionnaire
Soft copies [SPSS database*SG*600 participants updated 20th May*2017.sav] Hard copies [Participant's surveySG300*Control*SW*701971E]

3.Health screening data
Soft copies [SPSS database*SG*600 participants updated 20th Aug*2017.sav] Hard copies [Participant's health screening recordsSG300*Intervention*C*101472D]

4.Field notebooks for documentation of observations and findings Hard /soft copies [Journal recordings*RD*CherylWong_25th July 2018.doc]

5.Digital recording of focus groups for process evaluation and exit interview Soft copies [recording*Focus Group*process evaluation*19thSeptember2018.doc] Hard copies [Written notesExit Interview*22nd July2018]

Digital File formats: Audit checklist in excel spreadsheet(.xls) Participants' survey and health screening results data - SPSS (.sav) Journal recording and Audio recordings - Microsoft word (doc) and Nvivo 11 software (.nvp)

Physical File formats: In the locket cabinet, the 100 copies of the audit checklists would be filed according to the 5 major districts in Singapore (20 centres for each district)- SW, NW, C, NE and SE.

Awhile the 1200 participants'(600 X 2)survey would be divided firstly into control (600) or intervention (600) group, then subdivided into pre-intervention and post intervention and accordingly to the 5 major districts and arranged from their IC no from smaller number at the top to larger no. at the bottom for each district.

A picture of the recording of the field notebooks would be taken, dated and stored into the computer under the names of the respective program ambassador. The digital recording of focus groups for the process and exit interview would be named, dated and physically stored in the PI's computer. The hard copies of the note book recordings would be physically store in the locked cabinet at the completion of the research study.

Meta-data is not applicable to this research study.

3 Research Project Data Storage, Retention and Dissemination Details

3.1 Storage arrangements

Digital storage mechanisms:

During the data collection and entry period, data will be stored on the PI's laptop and a backup version of the research data files and documents would be created, updated on a weekly basis and stored in a separate computer to safeguard the data information. Multiple copies would be saved in external USB portable hard disk and stored in locked cabinet to minimize the risk of data loss or destruction. All relevant research data such as digital files and documents will be transferred and stored in Curtin's networked R drive provided by CITS to prevent hardware failure.

Plans for physical data storage:

Throughout the research project, the physical data such as audit checklists, questionnaires and note recordings will be securely stored in a locked cabinet at REHI Pte Ltd for minimum of 7 years in the PI's office.

3.2 Estimated data storage volume

We would estimate the total volume of data generated or collected to be around 10 GB - inclusive of SPSS data analysis files (participant's survey and health screening), word documents (participant's survey questionnaire, informed consent form, digital recordings from focus groups been transcribed using Nvivo 11 software, journal recordings by research team), excel documents (research budget and RCs audit checklist), PDF documents (programme flyers, health booklets and recipe booklet)and photos taken at multiple research study sites during the various stages of research planning, implementation and evaluation.

3.3 Safeguarding measures

As mentioned above under digital storage mechanisms, multiple copies in a different location would be arranged and

physical data would be kept in a locked cabinet that is only accessible to the PI. Backup copies would be made on a regularly basis (weekly)and to Curtin network drive to safeguard the data.

Media obsolescence would be prevented by ensuring standard, interchangeable and longer-lasting formats for all forms of the research data.

3.4 Retention requirements

7 years (All other research with outcomes that are classed as Minor)

3.5 Collaboration

This project is done in collaboration with my research supervisors from Curtin University and the research project data would be made available to them via Curtin R Drive.

Curtin Research Supervisors:

Associate Professor Jonine Jancey (Supervisor) Professor Andy Lee (Co-supervisor) Dr Tony James (Co-supervisor) Dr Jun Chih (Chairperson)

3.6 Data dissemination

Research project data could be promoted and disseminated by identifying and publishing with suitable journals in the field of health promotion or thru health related conference and poster presentation. Access to data will be made openly available and it would be deposited into espace@Curtin repository.

3.7 Embargo period

The research data will be embargoed from open sharing and made available to the community straight after all results and findings from the research data have been published.

Requests for data sharing before the end of the embargo period can be considered on a case-by-case basis between the PI and the respective research collaborators.

APPENDIX S: SEMI-STRUCTURED EXIT INTERVIEWS

Curtin University

Exit Interviews: Completers for Physical Activity and Nutrition Program

Participant Name: _____

Intervention site: _____

Objectives:

1. To seek reasons for taking part in the nutrition and fitness program.
2. To identify what features of this program has encouraged their participation.
3. To identify the level of guidance and support provided by the fitness trainer and nutritionists during the program.
4. To examine changes in attitudes/behaviours to physical activity and eating habits of the participants.
5. To identify ways on how the program can be further improved.

Method:
Qualitative interviews conducted via telephone call.

Interviewer Introduction:
Introduce yourself and reasons for conducting this 15 minute interview.

We are conducting brief interviews with some of the participants who have successfully completed the program. We would like to seek your views and feedback on the program as well as the guidance and support you have received from the fitness trainers and nutritionists. Thanks for your time for agreeing to participate!

Reasons for taking part in the program.

Firstly, I will like to ask you why you want to participate in the nutrition and fitness program.

1. What were the **reasons for getting involved** in this program?

_____

_____

Features of the program

Now, I will like to discuss with you on the features of this program (community-based program, health booklets, recipe booklet, dietary counselling sessions, nutrition talks, fitness classes and healthy text messages). I would like your opinions and feedback on the components of the program that you like or disliked.

2a. What did you think of the **program overall** (Prompt – timing of the session, venue, pace and sustainability of interest)?

_____

_____

2b. **What did you think of the health booklets, recipe booklet, dietary counselling sessions, nutrition talks, fitness sessions and text messages** overall? (Prompt –health booklets, recipe books: information content, readability and practicality; counselling sessions, nutrition talks, fitness classes and text messages: content coverage, frequency, intensity and duration).

2c. Do you have any suggestions to **improve** the program in terms of the materials given out (health booklets, recipe book) or the program (dietary counselling, talk sessions, fitness classes or text messages)?

Fitness Trainer / Nutritionists – guidance and support

We would like to get some feedback on the guidance and support you received from your fitness trainer / nutritionists.

3a. How would you **rate the guidance and support** you received from the fitness trainer using a scale of 1 - 10?

1 = not good and 10 = very good.

1…….2…….3…….4…….5…….6…….7……8…….9…….10

3b. How would you **rate the guidance and support** you received from the nutritionists using a scale of 1 - 10?

1 = not good and 10 = very good.
1…….2…….3…….4…….5…….6…….7……8…….9…….10

3c. What did you **like** about the guidance and support you received from them? (Prompt – clarity, presentation skills, approachability, knowledge, provide helpful and practical tips, gain new knowledge)?

3d. What did you **dislike** about the guidance and support you received from them?

Changes in attitudes and behaviours to physical activity and eating habits

I would now like to ask you about your attitude to physical activity since you started the program.

4a. Do you feel fitter after starting the program? If yes, in what way do you feel different? (Prompt – get more done, more aware of health, do something about health)

4b. Do you think the program encouraged you to **increase** your levels of physical activity? Why or why not? (Prompt – frequency and duration)

4b. Have you tried any new or **different types of physical activity** since starting the program (for example, Zumba, Bokwa, line-dance etc.)? Please list.

I would now like to ask you about changes in your eating habits since starting the program.

4c. Do you think the program has **encouraged** you to make any changes to your eating habits? Why or why not? (Prompt – eat more wholegrains, fruits & vegetables, cut down on sugar and salt etc.).

4d. Do you think the program has encouraged you to find out **more information** about food/nutrition? Why or why not?

4e. Are there any **changes** you made to your diet since starting the program? Please list.

_____
_____
_____

4f. Do you intent to be continue to be active? If yes, how often? With whom?

_____
_____

Lastly, I would like to ask you about your opinion on the program.

5a. What **motivated** you the most to complete the program?

_____
_____
_____

5b. How do you think we could make the program **more appealing** to your age group?

_____
_____
_____
_____

5c. Can you suggest how **the program can be further improved?**

_____
_____
_____
_____

5d. Would you **recommend** the program to your friends, family or relatives? Why or why not?

_____
_____
_____

5e. Any **other suggestions for improvement**?

_____
_____
_____
_____

Thank you for your precious time!
Your feedback will provide valuable information regarding the program!

Curtin University

Exit Interviews: Non-completers for Nutrition and Fitness Program

Participant Name: _____

Intervention site: _____

Objectives:

1. To seek reasons for taking part in the nutrition and fitness program.
2. To identify why they decide not to continue in the program.
3. To identify ways on how the program can be further improved.

Method:

Qualitative interviews conducted via face to face or telephone call.

Interviewer Introduction:

Introduce yourself and reasons for conducting this 15 minute interview.

We are conducting brief interviews with some of the participants who have started the nutrition and fitness program but has decided to discontinue the program. We would like to seek your views and feedback on the program as well as the guidance and support you have received from the fitness trainers and nutritionists. Thanks for your time for agreeing to participate!

Reasons for taking part in the program.

Firstly, I will like to ask you why you want to participate in the nutrition and fitness program.

1a. What were the **reasons for getting involved** in this program?

_____

_____

_____

_____

_____

1b. How **long did you participate** in the program for?

_____

_____

Reasons for not being involved in the program

I would like to talk to you about why you did not participate in the whole program.

2a. Would you like to tell me the **reasons for not continuing** the program? (*Optional – may not want to disclose. Move to next question)

_____

_____

2b. Are there any aspects of the program itself you **did not like**?

2c. Are there any aspects of the program itself you **did like**?

Program and Resources

Now, I would like to talk to you about the program and its resources.

2d. What did you think of the **program** (*community-based program, dietary counselling sessions, nutrition talks, fitness classes and healthy text messages)* **and its resources overall** (*health booklets, recipe booklets*)?

2e. Do you have any suggestions to **improve** the program and its resources? (Prompt –health booklets, recipe books: information content, readability and practicality; counselling sessions, nutrition talks, fitness classes and text messages: content coverage, frequency, intensity and duration).

Fitness Trainer / Nutritionists – guidance and support

We would like to get some feedback on the guidance and support you received from your fitness trainer / nutritionists.

2f. How would you **rate the guidance and support** you received from the fitness trainer using a scale of 1 - 10?

1 = not good and 10 = very good.

1.....2.....3.....4.....5.....6.....7.....8.....9.....10

2g. How would you **rate the guidance and support** you received from the nutritionists using a scale of 1 - 10?

1 = not good and 10 = very good.
1.....2.....3.....4.....5.....6.....7.....8.....9.....10

2h. What did you **like** about the guidance and support you received from them? (Prompt – clarity, presentation skills, approachability, knowledge, provide helpful and practical tips, gain new knowledge)?

2i. What did you **dislike** about the guidance and support you received from them?

Lastly, I would like to gain feedback on how we could have encouraged you to stay in the program.

3a. What could we have done to **encourage you to stay** with the program?

3b. Can you suggest how **the program can be improved** in terms of the materials given out (health booklets, recipe book) or the program (dietary counselling, talk sessions, fitness classes or text messages)? (Prompt – timing of the session, venue, pace and sustainability of interest etc.)

3c. Are there any **other suggestions** you would like to comment on improving the program?

3d. Would you **recommend** the program to your friends, family or relatives? Why or why not?

Thank you for your precious time!

Your feedback will provide valuable information to improve the program!

APPENDIX T: SELF-ADMINISTERED EVALUATION FORM

Curtin University

Evaluation Form 评价表

Course 课程:	Trainer 讲解员:
Location 地点:	Date 日期:
Participant's name (optional) 参与者的名字 (可选):	Department (optional) 部门 (可选):

Please circle the appropriate scale.
请圈选适当的选择。

	Excellent 非常好	Good 好	Satisfactory 令人满意	Fair 可接受	Poor 差
1. Programme 节目					
a. Pace 速度	5	4	3	2	1
b. Sustainability of interest 兴趣的可持续性	5	4	3	2	1
c. Overall rating of programme 总体评价	5	4	3	2	1
2. Trainer 讲解员					
a. Clarity 明晰	5	4	3	2	1
b. Presentation skills 表达技巧	5	4	3	2	1
c. Knowledge 知识	5	4	3	2	1
d. Approachability 易接	5	4	3	2	1
e. Overall rating of trainer 总体评价	5	4	3	2	1

3. Overall evaluation 总体评价

a. Would you recommend this programme to others? 你会推荐这个 节目给别人吗？

_____

_____

b. How could the programme be improved? 应该如何改善这个节目？

_____

_____

d. What other health activities or topics are you interested to have?
你对哪些其他保健活动或专题感兴趣?

_____

_____

e. Other comments 其他意见

_____

_____

_____

Thank you. 谢谢!

APPENDIX U: GENERALISED ESTIMATING EQUATIONS ANALYSES OF CONTINUOUS OUTCOMES BETWEEN THE TWO GROUPS FROM BASELINE TO POST-INTERVENTION (n =580)

Outcome	Estimated regression coefficient	95% confidence interval	*p* value	Intra-cluster correlation coefficient
Moderate physical activity (Metabolic equivalent of task mins/week) [a,c]	0.058	(0.227, 0.089)	<0.001	0.046
Total physical activity (Metabolic equivalent of task mins/week)	0.043	(0.021, 0.065)	<0.001	0.018
Walking and cycling physical activity (Metabolic equivalent of task mins/week) [a,c]	0.012	(-0.019, 0.043)	0.454	0.070
Sitting time (mins/week) [a,c]	-0.009	(-0.022, 0.004)	0.190	0.012
Systolic blood pressure (mmHg) [b,c]	-3.660	(-6.744, -0.576)	0.020	0.037
Diastolic blood pressure (mmHg) [b,c]	-3.455	(-5.417, -1.493)	0.001	0.030
Waist circumference (cm) [b,c]	-0.296	(-1.874, 1.281)	0.713	0.056
Hip circumference (cm) [b,c]	0.937	(-0.161, 2.034)	0.094	0.039
Waist-hip ratio [b,c]	-0.011	(-0.023, 0.001)	0.082	0.020
Weight (Kg) [b,c]	-0.325	(-0.651, 0.001)	0.051	-0.008
Body mass index (Kg/m^2) [b,c]	-0.157	(-0.322, 0.007)	0.061	-0.006
Body fat (%) [b,c]	-1.918	(-2.874, -0.961)	<0.001	0.025
Blood glucose (mM) [a,c]	0.003	(-0.041, 0.048)	0.884	0.130
Total cholesterol (mM) [b,c]	-0.047	(-0.156, 0.063)	0.402	0.002
Low-density lipoprotein-cholesterol (mM) [b,c]	0.005	(-0.134, 0.145)	0.942	0.024
Non-High-density lipoprotein-cholesterol (mM) [b,c]	-0.049	(-0.173, 0.074)	0.431	0.013
Cholesterol ratio [b,c]	-0.006	(-0.114, 0.101)	0.911	0.026
Triglyceride (mM) [a,c]	-0.004	(-0.061, 0.053)	0.885	0.010
High-density lipoprotein-cholesterol (mM) [b,c]	-0.014	(-0.057, 0.028)	0.506	0.029

[a] Gamma generalised estimating equations model with log link

[b] Normal generalised estimating equations model with identify link

[c] Adjusted for age, ethnicity, education level, marital status, housing type, health conditions, medication usage, clustering effect and the baseline outcome measure.

APPENDIX V: ACCELEROMETRY DATA FOR A SUB-SAMPLE OF SELF-SELECTED INTERVENTION PARTICIPANTS (n=65)

PA outcomes	Intervention group		Difference Mean (SD)	95% confidence interval	*p* value [a]
	Baseline Mean (SD)	Post-test Mean (SD)			
Moderate PA (MET mins/week)	164.01 (117.05)	237.74 (144.56)	+73.73 (144.96)	(37.81, 109.65)	<0.001
Total PA (MET mins/week)	1342.17 (464.51)	1649.84 (811.40)	+307.67 (792.86)	(111.21, 504.13)	0.003
Vigorous PA (MET mins/week)	4.13 (7.71)	5.38 (7.68)	+1.25 (6.12)	(-0.27, 2.76)	0.106
Sedentary behaviour i.e. sitting time (mins/week)	5578.22 (5440.49)	5492.64 (3062.90)	-85.58 (6078.08)	(-1591.66, 1420.49)	0.910

[a] Paired t-test between baseline and post-test for the intervention group.

APPENDIX W: GENERALISED ESTIMATING EQUATIONS ANALYSES OF BINARY OUTCOMES BETWEEN THE TWO GROUPS FROM BASELINE TO POST-INTERVENTION (n =580)

Outcome	Adjusted odds ratio	95% confidence interval	*p* value	Intra-cluster correlation coefficient
Vigorous physical activity n (%) [a,b]	11.126	(4.240, 29.197)	<0.001	-0.006
Frequent fruit intake [a,b,c]	2.240	(1.398, 3.588)	0.001	0.006
Frequent vegetables intake [a,b,e]	1.582	(1.002, 2.497)	0.049	0.015
Frequent wholegrain intake [a,b,d]	1.809	(1.026, 3.190)	0.041	0.009
Frequent salt and salty sauce intake [a,b,d]	0.548	(0.306, 0.979)	0.042	0.016
Frequent sugary beverage intake [a,b,e]	0.529	(0.310, 0.902)	0.019	-0.015
Frequent fatty food intake [a,b,e]	0.991	(0.601, 1.635)	0.973	-0.005

[a] Logistic generalised estimating equations model

[b] Adjusted for age, ethnicity, education level, marital status, housing type, health conditions, medication usage, clustering effect and the baseline outcome measure.

[c] At least two servings per day

[d] At least once per week

[e] More than three times per week

APPENDIX X: GENERALISED ESTIMATING EQUATIONS ANALYSIS OF HEALTH-RELATED QUALITY OF LIFE OUTCOMES BETWEEN THE TWO GROUPS FROM BASELINE TO POST INTERVENTION (n=580)

Outcome	Adjusted odds ratio	95% confidence interval	*p* value	Intra-cluster correlation coefficient
Good health rating [a,b,c,d]	0.485	(0.171, 1.381)	0.175	-0.001
No physical health issues in limiting PA [a,b,c,e]	0.909	(0.424, 1.952)	0.807	-0.009
No difficulty in doing daily activities [a,b,c,f]	0.578	(0.129, 2.588)	0.474	0.007
No body pain [a,b,c,g]	1.709	(1.027, 2.843)	0.039	-0.008
High energy levels [a,b,c,h]	0.616	(0.348, 1.089)	0.095	-0.008
No physical or emotional problems that limit social activities [a,b,c,i]	0.710	(0.436, 1.157)	0.169	0.004
Not bothered by emotional problems [a,b,c,j]	0.568	(0.309, 1.045)	0.069	-0.009
No personal or emotional problems in limiting daily activities [a,b,c,k]	0.770	(0.461, 1.288)	0.320	0.005

[a] Logistic generalised estimating equations model.

[b] Adjusted for age, ethnicity, education level, marital status, housing type, health conditions, medication usage and the clustering effect.

[c] For the past four weeks

[d] Rating of 'fair to excellent' health status

[e] Rating of 'none to some' physical health problems in limiting physical activities

[f] Rating of 'none to some' difficulty in doing daily activities

[g] Rating of 'none to mild' bodily pain

[h] Rating of 'some to high' energy level

[i] Rating of no physical or emotional problems that limit social activities

[j] Rating of not bothered by emotional problems

[k] Rating of 'none to very little' personal or emotional problems in limiting daily activities

APPENDIX Y: POLICY BRIEF – EFFECTIVENESS OF THE SPANS INTERVENTION

Lifestyle Behavioural Interventions to Tackle Chronic Diseases in Community-Dwelling Older Adults

High economic burden of NCDs

With a rapidly ageing population and urbanisation in Singapore, non-communicable diseases (NCDs) are responsible for more than 80 per cent of the total disease burden and cost the nation more than US$9 billion annually (Khalik, 2017). Cardiovascular disease, cancer and diabetes are the most prevalent NCDs that have far-reaching, undermining effects on the social, economic and mental well-being of older adults, especially for 'at-risk' inactive Singaporean women aged above 50 years with poor dietary habits (Wong, Lee, James, & Jancey, 2018).

Implement 'best buys' lifestyle interventions

The World Health Organisation (WHO) has argued that NCDs are largely preventable by cost-effective intervention strategies, recognised as 'best buys' such as physical activity (PA) and healthy diets to combat NCDs (WHO, 2017). The Singapore Physical Activity and Nutrition Study (SPANS), a potential primary prevention lifestyle intervention was implemented and evaluated at Singaporean recreational centres (RCs) of proximity to 80% of Singaporean population residing in government housing to support healthy aging practices (Wong, Lee, James, & Jancey, 2019).

Create health-enabling communities

The findings from the SPANS improved PA and dietary behaviours, reduced systolic and diastolic blood pressure and body fat percentage for the intervention group compared to the control group over six months. The participants of the SPANS reported high satisfaction levels for the program, resources and program ambassadors. The appropriate resources, personalised sessions and motivational support from program ambassadors facilitated positive behaviours and drove a greater desire in engaging healthy lifestyle behaviours among participants to improve their health status.

Overcoming NCD health threats

A plethora of evidence has proven that NCDs can be prevented or delayed by lifestyle behavioural interventions focusing on PA and dietary modification (Zubala et al., 2017). There is an urgent call to action for policymakers, health professionals and researchers to improve the health and well-being of older adults by motivating them to engage in primary prevention intervention at the RCs to ease pressure on healthcare resources and reduce long-term healthcare costs. Strong partnerships between public and private organisations with the government and the individual are paramount to instigate impactful PA and healthy eating practices to reduce the high rates of NCDs in Singapore.

Appendices

See Appendix Y: Infographics poster – Get Active, Stay Healthy at RCs!

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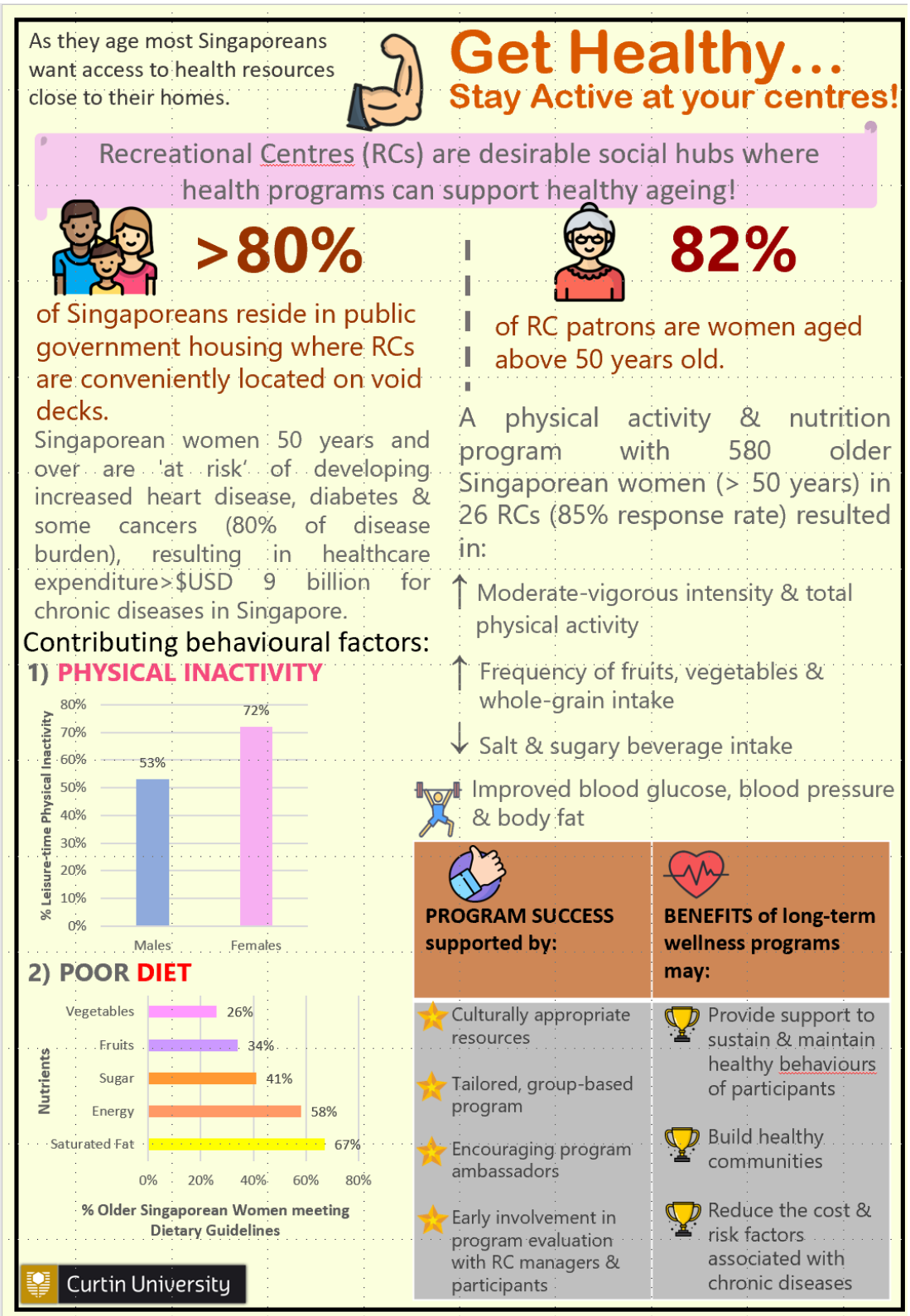
APPENDIX Z:
INFOGRAPHICS POSTER - GET ACTIVE, STAY HEALTHY AT RCs!



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