School of Psychology

Dyadic Interventions to Promote Physical Activity

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DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made. This thesis 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 in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), approval number: HRE2017-0045-04.

Signed:

Date: 5th July 2019

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DEDICATION

This thesis is dedicated to the memory of my grandma who encouraged me to pursue my Doctor of Philosophy degree.

LIST OF PUBLICATIONS INCLUDED AS PART OF THE THESIS

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ABSTRACT

PA interventions have typically focused on individuals or groups, but there is increasing research on dyadic approaches to PA promotion. This thesis presents the first systematic review and meta-analysis of dyadic interventions for PA (k=59) (Chapter 2). Findings showed that dyadic interventions had a small positive effect on PA, relative to comparison conditions, including those targeting individuals. The largest effect sizes where found when both dyad members held the same PA goal for the main target of the intervention. Peer/friend dyads were associated with larger effect sizes than other types of dyads across most analyses.

Chapter 3 explored the utility of using collaborative plans and motivation training, for postpartum mothers and a study partner (mainly the father). Participants through random allocation received 1 of 3 dyadic conditions: a minimal treatment control (n = 34), collaborative planning (n = 38), or collaborative planning with need supportive communication training (n = 30). A small positive effect on total PA at follow-up was found for mothers in the collaborative planning group and for partners in the collaborative planning + need supportive communication group. Unexpectedly, at the follow-up, mothers in the collaborative planning + need supportive communication group scored lower on personal autonomous reasons; in the same group and at the same time point, partners scored lower on confidence in their partner's support.

These findings were further explored by interviews with a subset of dyads (n = 27) (Chapter 4). Benefits of the program included providing accountability and commitment. Childcare commitments, lacking motivation or selecting the wrong study partner explained why PA was not always possible.

Overall dyadic interventions were shown some promise in a hard-to-reach population but future considerations and suggestions for dyadic interventions are discussed.

CHAPTER ONE: Review of the Literature

The Problem of Physical Inactivity

There are many benefits to undertaking regular physical activity (PA). Regular PA improves bone health, cognitive function, cardiorespiratory and muscle fitness (Lee et al., 2012). Increased PA can also assist in improving risk factors associated with cardiovascular disease, even in the absence of weight loss (Shaw, Gennat, O'Rourke, & Del Mar, 2006). A higher level of leisure-time PA is also associated with lower risk for 13 out of 26 types of cancer (Moore et al., 2016). Regular PA is associated with decreased levels of depression and burnout in patients with stress-related exhaustion (Lindegård, Jonsdottir, Börjesson, Lindwall, & Gerber, 2015). PA also reduces depression and anxiety in non-clinical populations (Rebar, Stanton, Geard, Short, Duncan, & Vandelanotte, 2015). Guidelines by the Australian Government suggest a minimum of 150 minutes of moderate intensity activity each week (Department of Health, 2017). Despite this, nearly 1 in 3 adults in Australia self-reported being insufficiently active on the National Health Survey 2014 (Department of Health, 2017). Globally, in 2016, 28% of adults were insufficiently active (World Health Organisation, n.d.). However, self-report responses such as the National Health Survey may underestimate the percentage of adults being inactive, as they are prone to poor recall and participants show a lack of understanding of the survey's requirements ("Physical activity and sedentary behaviour," n.d.). Physical inactivity levels could be much higher than estimated. Increasing PA is thus, a public health priority. Hence, there is an upsurge in interventions targeting PA change.

Theoretical approaches to behaviour change

The most prominent theories in the PA literature according to Nigg, Borrelli, Maddock, and Dishman (2008) are the Theory of Planned Behaviour (TPB), the Transtheoretical Model (TTM), Self-Determination Theory (SDT), and Social Cognitive Theory (SCT). The TPB by Ajzen (1985) indicates that individuals will engage in a behaviour like PA if they have strong intentions and positive evaluations of being active and believe that PA is both under their control and encouraged by their significant others (Buchan, Ollis, Thomas, & Baker, 2012). Alas, the TPB is primarily focused on an individual's attitude, intention, beliefs about subjective norms, and personal feelings of control. TTM is concerned with how individuals pass through specific

stages depending on their readiness to change (Buchan et al., 2012), from precontemplation (no intention of changing behaviour), to contemplation, preparation, action, and finally maintenance (Marcus & Forsyth, 2003). SDT (Ryan & Deci, 2000) aims to identify the motivation that lead individuals to act. For example, some people regularly engage in PA simply for enjoyment, while others exercise to attain intrinsic or extrinsic rewards, increased attractiveness, losing weight, or recognition from loved ones (Deci & Ryan, 2000). Similarly, SCT (Bandura, 2001) focused less on the individual and more on the social and physical environment. SCT explains PA behaviour in terms of a triadic model in which an individual's personal factors (cognitions and characteristics), behaviour, and the environment influence each other (Bandura, 1986, 1997). Normative influences such as social approval, rewards, and punishments promote behaviour (Bandura, 1986). People engage with a behaviour partly based on their self-efficacy and beliefs. Efficacy is represented as an individual's evaluation of their knowledge and actions, and whether they have the information and belief that they can avoid negative outcomes (Burke et al., 2009). For example, knowing how to overcome obstacles to PA and feeling confident enough to negate these barriers and avoid detrimental outcomes (e.g. obesity). People select, construct and negotiate environments depending on their self-belief of efficacy (Bandura, 1994). For example, they can break out of their typical routine and select social environments that promote PA. Again, even though SCT recognises the influence of close others on behaviour, it focuses primarily on the individual's efficacy and their own self-beliefs. Collectively current psychological theories are focused primarily on the individual, even though they may recognise the power of social influence.

Adults often live in close relationships and health behaviour change happens within a social context (Burkert, Knoll, Luszczynska, & Gralla, 2012). Berkman, Glass, Brissette, and Seeman's (2000) conceptual model of how social networks influence health emphasises that social networks provide opportunities for close personal and intimate contact (e.g., sexual), social influence (e.g., peer pressure) and social engagement (e.g., bonding). They emphasise how these mechanisms influence traits including self-esteem, self-efficacy and security which in turn, are pathways to health status.

The importance of focusing on dyads or groups

An individual's decision to engage in PA (or refrain from doing so) can be influenced by close friends, romantic partners or family members. Leahey, Kumar, Weinberg, and Wing (2012) found that during a team-based weight loss and PA intervention, weight loss was similar among teammates and, a 1-unit increase in self-reported teammate social influence for weight loss increased the odds by 20% of achieving a clinically significant weight loss. Thus, it is important to focus on not only the individual but the wider group of romantic partners, friends, and significant others. There are advantages to recruiting dyads rather than groups for behaviour change interventions. Although, a concern may be that if one dyad member puts less effort into increasing PA, then their partner may lower their efforts in response (matching of efforts theory; Jackson & Harkins, 1985) the Ringelmann effect (Ingham, Levinger, Graves, & Peckham, 1974) states that as group size increases, individual behaviour may be less productive (Czyż, Szmajke, Kruger, & Kübler, 2016). In people who were new to team sports, Czyż and colleagues (2016) found that the results of 2-member teams were better than expected. Further in the same study, the more individuals within a group, the lower the efforts made by each member of the group. Thus, recruiting a group of 2 means that individuals are less likely to give into 'social loafing' than a larger group while having the benefits of increased social support.

Further, the effects of group research might not generalise to dyads, as dyads are a unique type of group and may have similar PA levels. For example, research shows positive correlations between couples' health behaviours (Arden-Close & McGrath, 2017). Some analyses have also shown that other types of dyad e.g., parents and children also have significant and positively related health behaviours (Nebeling et al., 2017). Utilising dyads in interventions means that we can explore similarity between partners on PA and the factors that might explain this similarity (Nebeling et al., 2017).

Thrasher, Campbell, and Oates (2004) explored to whom people would turn to for social support to improve different health behaviours. Only 6% of people said they would not turn to anyone for social support in increasing PA. Most people would turn to a spouse or partner or to other family members for support (37% family member, 25% spouse, 23% friend, 9% doctor). These findings collectively illustrate the importance of close significant others for increasing PA. People in close relationships, engage in healthier behaviours when their partners report less use of negative social control strategies (e.g., guilt, withdrawal, expressing negative emotions; Burke

& Segrin, 2017). People's health behaviours were unrelated to their partner's use of positive social control strategies (e.g., making suggestions, expressing positive emotions, and praise). However, people who gave positive social control messages to their partner engaged in healthier exercise and diet behaviours themselves (Burke & Segrin, 2017). Thus, people in close relationships appear to have more healthy behaviours as a result of their partner's and their own social control attempts. A small number of studies have tested the efficacy of dyadic PA interventions involving romantic partners (e.g., Knoll et al., 2017) or one significant other (e.g., Prestwich et al., 2012). Prestwich and colleagues asked local government employees to choose another person (e.g., a family member, spouse or friend) to plan to engage in PA together and this led to greater PA change (on their self-reported walking and exercise tables) in the target dyad member than planning to exercise individually or not planning. This finding illustrates how dyad partners can increase each other's PA.

Transactive Goal Dynamics theory (TGD)

TGD theory provides a theoretical context in which we can explore the dyadic/ spousal relationship. Fitzsimons and colleagues proposed the TGD theory (Fitzsimons, Finkel, & vanDellen, 2015) and applied it specifically to dyads (see Figure 1). Thus, exploring the role of TGD theory may help us to understand the influence of close dyadic relationships on PA. According to TGD, there are numerous interpersonal factors that contribute to the attainment of goals for both dyad partners. These factors include transactive density (the number of links between goals, pursuits and outcomes), goal coordination (how well the goals fit together) and relationship orientation (how dedicated the partners are to the persistence and well-being of the relationship). For example, cohabiting couples who both want to run a marathon, have high goal coordination (from having the same goal) and high transactive density (from living together). If this couple were facing conflict with each other, they would likely have more independent goal pursuits and would not choose to run the marathon together. If this couple had a satisfying relationship and valued being interdependent, they would be more likely to run together. Within each partner's goal pursuit is a multitude of relationship factors (e.g., opportunities for independence, expectations about interdependence) that drive the pursuit towards individual or shared goals. Transactive density refers to how strongly and often two partners' goals, pursuits and outcomes affect each other (Fitzsimons et al., 2015). For example, imagine a person who has

just joined the gym. If they had just started a relationship, then this may slightly affect their new partner's goal of wanting to spend lots of time together (low transactive density). If the same

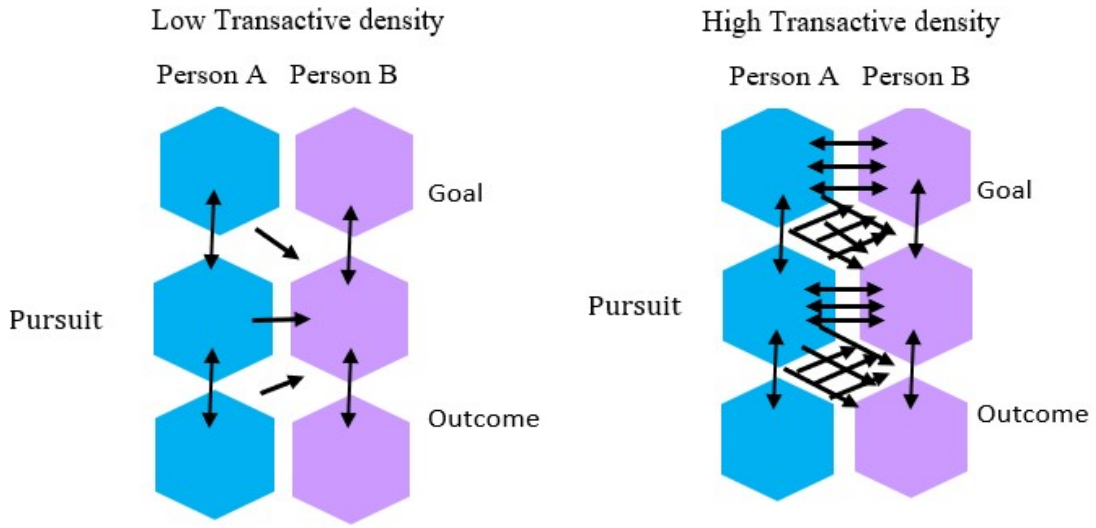

Figure 1. Transactive Density According to TGD theory adapted from Fitzsimons et al. (2015)

Note. The figure on the left shows a dyad with few links between their goals, pursuits and outcomes (low transactive density). The figure on the right shows numerous links between dyad partners' goals, pursuits and outcome (high transactive density).

couple were together for many years, then this may affect their partner's goals of buying a house together, having family time, or socialising with friends (high transactive density). Based on this theory, to promote PA shared goals need to be promoted between the dyad members as then it is possible for dyad partners to share and divide resources and facilitate each other's pursuit of the goal (Fitzsimons et al., 2015).

Table 1

Transactive Goal Dynamics Theory (adapted from Fitzsimons et al., 2015)

Type of goal	Example
Self-oriented goal	A mother has a goal to increase her own PA
Partner-oriented goal	A mother has a goal for her partner to increase PA
System-oriented goal	A mother has a goal for herself and her partner to increase PA
Parallel self-oriented goal	A mother and her partner both have a goal to

	increase their own PA
Parallel partner-oriented goal	A mother has a goal to increase her partner's PA but instead her partner wants her to increase PA
Shared target-oriented goal	A mother has a goal to increase her own PA and her partner wants that too
Shared system-oriented goal	Both the mother and her partner want both to increase PA

Couples

Although there is theoretical evidence for how PA interventions can promote shared goals among dyads to enact behaviour change, most PA research on dyads is correlational rather than experimental. Research has shown people eat healthily or engage in PA when those behaviours are supported by their romantic partners (Thrasher et al., 2004). For example, Li, Cardinal, and Acock (2013) studied 5,047 married couples aged 50+ and found spousal concordance in PA and that PA declines with age. Husbands' PA was slightly more dependent on their spouses' activity than vice versa. When wives' PA decreases, their attempts to change their husbands' activity may also decrease resulting in lower activity for both (Li et al., 2013). Schierberl Scherr, McClure Brenchley, and Gorin (2013) explored whether change in one spouse can result in change in their partner, from either a) both actively participating in a weight loss intervention or b) a ripple effect from a treated spouse to an untreated spouse. Schierberl Scherr and colleagues enrolled 132 heterosexual couples in an 18-month weight loss and PA program, involving group meetings and training in core behavioural skills (e.g., self-monitoring, problem solving, goal-setting). The intervention focused on increasing partner involvement and making alterations in the home environment (e.g., adding a treadmill, serving size appropriate dishware, and posters). There were no significant PA changes for either partner, regardless of whether participants attended the treatment together or the primary participant attended alone. There were no reciprocal effects between the PA changes of spouses at 6 months. Weight loss was greater if both participants and partners were treated; untreated partners' weight loss was positively impacted by their spouses' dietary changes, suggesting a ripple effect. Schierberl Scherr and

colleagues explained these findings by suggesting that changes in diet are easier to make in the shared spousal home environment than changes in PA.

Participating Together

Alas, there is an emerging area of research focusing on the benefits of having a partner or significant other co-participate in a PA intervention (Gellert, Ziegelmann, Warner, & Schwarzer, 2011), one-way partners can participate is by developing shared goals. Although the literature recognises how social relationships and action control/planning influence behaviour change, these constructs have been examined largely independent of each other (Berli, Stadler, Inauen, & Scholz, 2016). According to Prestwich and colleagues (2012) greater partner involvement, such as when partners contribute to behavioural planning and develop shared goals, should lead to greater heath behaviour change. McSpadden, Patrick, Oh, Yaroch, Dwyer, and Nebeling (2016) found that social support from friends and family and autonomous motivation was positively related to fruit and vegetable intake, controlled forms of motivation (e.g., social approval or rewards, or guilt avoidance) were negatively related to fruit and vegetable intake. Social support was positively related to PA when couples participate together in an intervention, but negatively related when partners do not participate or in people who are single (Gellert et al., 2011). This finding could be because couples provide mutual exercise support when they take part in an intervention together (Gellert et al., 2011).

Alas aiming for both dyad members to exercise together and develop shared system-oriented goals can also be counterproductive, for example when there are insufficient opportunities or strong barriers to exercising together (Knoll et al., 2017). The medical necessity to exercise may not apply equally to both partners. For example, Knoll et al. (2017) refers to two cases where one spouse needs to change their behaviour either for preventative means (e.g., breast self-examination) or recovery (e.g., exercises post-surgery or illness). However, Winters-Stone et al. (2016) found targeting the health of both prostate cancer survivors and their spouses by emphasising motivation and team work led to mutual PA benefits. Such benefits are more likely because committed partners within dating relationships are more likely than non-committed partners to be motivated to get involved in each other's goals and pursuits and develop shared goals (Fitzsimons et al., 2015). For example, in Winters-Stone and colleagues' study the prostate cancer survivor exercised while their spouse assumed the role of coach, and

then the roles were switched (a shared system-oriented goal). Highly satisfied and committed relationship partners are also more likely to possess shared goals, because they place more value upon each other. To better understand dyadic PA changes, interventions would benefit from improving relationship dynamics among couples that might impact their success for affecting change in one another (Schierberl Scherr et al., 2013). For example, it is possible that, in PA interventions, one spouse is more supportive than the other. Exploring how to motivate both partners equally would be an important avenue for future research. Researchers have been interested in the spouse's influence on health behaviours (e.g., weight loss and physical activity; see Schierberl Scherr et al., 2013). The influence of friends on health behaviours has not been compared to spousal influence. Reciprocal relationships among spouses for weight may not apply to friends or other family members (Schierberl Scherr et al., 2013). Thus, different types of dyads may also vary in their influence on PA; this has not been addressed in the literature.

Friends and Peers

Part of the reason there are many more studies on friends dyads as opposed to romantic couples dyads is because the former studies have typically focused on children or adolescents. For example, Lopes, Gabbard, and Rodrigues (2012) found in a sample of 268 adolescents (aged 13-18 years old), that "best friend" dyads had similar PA levels. Jago et al. (2011) also found 10-11-year-old children's mean moderate vigorous PA (MVPA) was positively associated with their best friend's MVPA. In addition, children who engaged in activity at home or in their neighbourhood *together* with their best friends, undertook more minutes of MVPA than those who did not (Jago et al., 2011). This indicates that exercising *together* with a best friend is associated with higher levels of PA.

Planning

Collaborative implementation intentions (Gollwitzer, 1993) involve dyads planning when and where they will perform a behaviour (e.g., PA) in the form of an if-then statement (i.e., if it's situation X, then WE will do Y). Prestwich et al. (2012) found when participants and a significant other set collaborative implementation intentions to exercise they had greater PA than participants who planned individually or did not make a plan. In contrast to collaborative planning, dyadic planning involves creating plans for one dyad member to act, not for both to act (Knoll et al., 2017). Hagger and Luszczynska (2014) suggested a research priority is to compare

planning individually vs collaboratively with a partner (e.g., dyadic plans) to achieve health goals. It is recommended to compare these as the use of dyadic or collaborative implementation intentions promotes social processes that may increase the strength of the link between the cue (e.g., sunny weather) and action (e.g., going for a walk) (Hagger & Luszczynska, 2014). However, the findings on dyadic plans show limited success. Dyadic plans have been found to have some benefit for health behaviours; for example, Burkert, Scholz, Gralla, Roigas, and Knoll (2011) found participants increased their frequency of pelvic floor exercises when they made dyadic plans with their romantic partner (measured up to 3 and a half weeks post-intervention), but two active control groups also increased their frequency of pelvic floor exercises. Knoll et al. (2017) asked couples to form five implementation intentions to increase the target persons' PA. They found beneficial effects of dyadic planning on PA but they were short-lived and did not last 6-weeks after the 1 day intervention. Therefore, we need to look at how to increase motivation to engage in PA in the longer term.

Promoting Motivation

SDT (Ryan & Deci, 2000) aims to identify the underlying motivation that lead individuals to act in certain health contexts. People are motivated to pursue a behaviour by extrinsic (non-self-determined motivation) and/or intrinsic (self-determined) motivation (Ryan & Deci, 2000). Depending on the motivation behind the behaviour, behaviours are regulated by the following factors: external contingencies (*external regulation* e.g., compliance, financial incentives, rewards and punishments); internal rewards and punishments (*introjected regulation* e.g., ego enhancement, avoiding blame or embarrassment or guilt); the value in the activity and its personal importance (*identified regulation* e.g., the activity is beneficial for one's well-being); integrating the activity into one's sense of self (*integrated regulation* e.g., the activity is part of one's core identity); satisfaction in the activity (*intrinsic regulation* e.g., personal enjoyment or interest). The latter three regulations are autonomous motivations, whereas external and introjected regulations are controlled motivations. There is evidence from a systematic review for the positive role of autonomous motivation. Specifically, it has been shown that identified regulation predicts initial adoption of exercise while intrinsic motivation predicts more long-term exercise adherence (Teixeira, Carraça, Markland, Silva, & Ryan, 2012).

Few studies in Teixeira et al.'s (2012) review tested integrated regulation but it seemed to also be associated with exercise behaviour. These motivational regulations have been manipulated in interventions such as the Promotion of Health and Exercise in Obesity (PHEO) intervention by Silva et al. (2008, 2010). This program was designed to promote autonomous motivation of women in Portugal by emphasising using neutral language (e.g., "may" and "could"), encouraging choice, and avoiding pressure, demands and extrinsic rewards. A dance class and PA challenge program was offered as part of the PHEO program to promote fun and experimentation with new activities. At 12 months, MVPA and step counts were higher in the intervention participants compared to those in the control. It was found that the need supportive communication style from the intervention improved autonomous motivation that in turn, promoted PA.

How people are supported or not by significant others when trying to increase their PA can affect their feelings of autonomy (feeling in control over PA-related choices), competence (being able to master PA-specific skills) and relatedness (feeling connected to the people you engage in PA with) in relation to PA (see Ryan & Deci, 2000). For example, tangible rewards (e.g., providing rewards only if someone has lost weight regardless of their increase in fitness), threats (e.g., for not engaging in PA), and imposing goals (which do not suit the individual), diminish intrinsic motivation (Ryan & Deci, 2000). In contrast, providing choice, acknowledging feelings, and opportunities for self-direction, enhance autonomy (Deci & Ryan, 1985). Alas, the literature needs to focus on an integrative form of motivation that combines the needs of both autonomy and relatedness (see Gore, Hester, Spegal, Kavanaugh, & Nakai, 2018), as they work in tandem. Inviting a similar-minded person into pursuing the goal is important as well as making sure that dyad partners both think the goal is worth pursuing (Gore et al., 2018). If people have the same positive attitude towards the importance of the goal this works to foster the right kinds of social support (e.g., focusing on enjoyment and love of the activity).

Relational Factors that Enhance Motivation

In close relationships significant others may unintentionally be giving the wrong kind of social support (such as pressuring a partner into engaging in PA as opposed to promoting enjoyment for PA). Not all social support is equally helpful (van Dam et al., 2005); inappropriate support can have negative consequences for self-determined motivation and need satisfaction

(Williams et al., 2006). Depending on the extent to which each partner has shared goal representations and responds to their partner, perception of being pressured could be more likely in transactively dense relationships. People in transactively dense relationships are dependent upon one another, and their goals are often interdependent. This means that if one partner wants to pursue a goal, but their partner does not have the same goal, then they may pressure their partner to change their goal. For example, if their partner wants to lose weight, but they want to indulge at several new restaurants) then consideration of one's own immediate happiness (vs. future health outcomes for their dyad partner) could lead to disruptive or even undermining a partner's behaviour (Berzins, LaBude, & Gere, 2018). In contrast, if the needs of the relationship align with the person's goals for themselves then they are more likely to have effective goal pursuit. Partners can incorporate the needs of the relationship into the reasons for why a goal is pursued (Gore et al., 2018). People in close relationships with high transactive density possess goals for themselves, their partner, and their relationship (e.g., one person might have both a partner-oriented goal for their spouse to lose weight and a goal for the relationship of getting married and having children).

Parenthood

Mothers and fathers have high interdependence (high transactive density) and many shared goals so fostering a need supportive environment between parents is key to increasing their PA. Parents also have many external pressures (e.g., spouse and work commitments, childcare responsibilities, household chores) and often struggle to find the time to exercise or if they find the time to exercise they may be too tired (Berge, Larson, Bauer, Neumark-Sztainer, 2011). The onset of parenthood appears to be related to the decline in MVPA (Rhodes et al., 2014). A systematic review by Allender et al. (2008) found three studies by Bell and Lee (2005), Brown and Trost (2003) and Barnekow-Bergkvist, Hedberg, Janlert, and Jansson, (1996) that collectively showed parenthood is associated with decreased PA participation. Furthermore, in surveys completed by 1030 men and 1257 women, both mothers and fathers were found to have lower amount of PA compared to non-parents, while many dietary behaviours were the same between parents and nonparents (Berge et al., 2011). To increase the PA of both parents we need to focus on the interaction between the couple (e.g., how often do they talk to each other), the social support they provide each other (e.g., how do they encourage each other to exercise) and

the roles each partner fulfils in parenthood (e.g., who looks after the baby, so their partner can exercise?) (adapted from Bellows-Riecken & Rhodes, 2008). Although the roles of both parents and the interactions between the couple are important for promoting PA, research often neglects fathers' health outcomes.

There is a striking lack of research on determinants of perinatal fathers' weight gain (Jarrett, 2018). However, when this research does exist it finds that mothers are more at risk of inactivity or weight-related implications, Berge et al. (2011) found that young adult mothers are at increased risk of a higher BMI than non-parents, but the same cannot be said for fathers. Most parents in that study had children who were one year old or younger. The non-significant finding for fathers' BMI may be because fathers in the study were young and are early in establishing their dietary and PA patterns (Berge et al., 2011). In contrast a 15-year longitudinal study by Umberson, Liu, Mirowsky, and Reczek (2011) found fathers weigh on average 14 pounds more than childless men. The mean age of fathers in Umberson and colleagues' study was 54 years. In Berge et al.'s (2011) study chronic disease risk and other weight-related implications from prolonged inactivity may not have started due to the fathers' young age. The postpartum period is a crucial time to engage parents in a PA intervention to reduce disease risks from prolonged inactivity and weight gain. Thus, examining how fathers can support mothers to engage in PA may be crucial in understanding and preventing PA decline among parents.

Planning and Parenthood

Given the demands of parenthood, parents may need to plan when they schedule their PA into their life as well as how to deal with obstacles (e.g., child illness). Dyadic/collaborative planning may thus, be particularly relevant to parents. Implementation intentions involve specific plans specifying how, where and when the target behaviour will be pursued. Parents often face several disruptions to their routines (e.g., child illness, spouse work commitments, childcare responsibilities). Key barriers to increase the PA of mothers include lack of childcare and dependence on husband/partner to provide child supervision (Cody & Lee, 1999). Creating an implementation intention with a romantic partner has been associated with the formation of rather specific physical activities (I will do X) but less specific situations to act (in situation Y) (Keller et al., 2017). This could be because the partner attempted to keep the planned future situation as flexible as possible to evade anticipated barriers (Keller et al., 2017). Thus, it seems

involving a partner when planning to exercise may also help parents to make more intuitive and realistic plans.

There is also empirical evidence of the effects of using implementation intentions to increase family PA (e.g., Rhodes, Naylor, & McKay, 2010). However, Rhodes et al. (2010) emphasise that identifying barriers to the use of planning materials can be helpful for identifying future intervention approaches that will work for most families. Rhodes et al. found that in a self-reported family implementation intention intervention, laziness, busyness/lack of time, and forgetfulness were the most common barriers to using the planning materials provided. The barrier of laziness, the authors argued, suggests that although overall family PA increased from their intervention, more focus on motivation rather than family regulation of PA may have helped some participants.

Motivation and Parenthood

There is evidence that relational motivation (e.g., the activity strengthens the relationship between me and my partner) may be particularly important for increasing the PA of parents. Gore et al. (2018) asked 186 parents to list an important health goal and rate statements regarding their relational experiences and their children's involvement in their goals. They found that having a child who shares the values of living a healthy lifestyle and who is directly involved with the parent's health goals promotes relational autonomy for health behaviours (e.g., PA). However, although the values of the whole family are important, Thornton et al. (2006) found that pregnant and postpartum Latino dyads reported being primarily influenced by their husbands on issues concerning weight and PA. In most instances husbands' companionship for eating meals and exercising, influenced participants to eat regularly and engage in PA occasionally. Emotional and informational support from the husband was the most important factor influencing the women's weight, diet and PA. Husbands were reported to tell their wives to exercise to lose pregnancy weight so they would not become "fat" or ill thus, thus, relying more on external motivation. Controlled motivation reflects feeling compelled to do something because of internal or external pressure (e.g., being told to do something by someone else) (Sheldon & Elliot, 1998). The results of three studies and a meta-analysis indicate that unlike autonomous motivation, controlled motivation is not related to goal progress (Koestner, Otis, Powers, Pelletier, & Gagnonet, 2008). However, surprisingly, the husbands' efforts to promote

exercise in their wife post-pregnancy in Thornton and colleagues' study usually resulted in women engaging in more PA. Alas, some participants felt their husband's support was both humiliating and involved harsh criticism, particularly in relation to weight. In such instances when husbands made criticising comments, participants' excess weight gain fuelled marital conflict but not weight change.

Couples may need help in terms of communicating with each other in need supportive ways to foster autonomous motivation. Mothers can assimilate their spouse's intrinsic motivation and value placed on the activity into the reason why they (mothers) pursue the goal. For example, if a mother perceives their spouse is motivated to be physically active because of intrinsic reasons, this increases the mother's intrinsic motivation (i.e., the contagion motivation effect; Radel, Sarrazin, Legrain, & Wild, 2010). Rather than just focusing on "initiating PA", increasing autonomous motivation in parents whether it is personal or relational, promotes longer-term behaviour change. Involving partners in interventions means that participants can rely on both relational autonomous motivation and personal motivation, so they have reasons to pursue the goal if their personal motivation is lacking. Both the individual's and the close other's interests are factored into the reason why a goal is pursued, so this promotes long-term goal attainment (Gore, Bowman, Grosse & Justice, 2016).

The Present Thesis and its Significance

Humans are social beings and are surrounded by networks of friends, family and romantic partners. People thus, rarely try to change their PA (or refrain from doing so) in isolation. Despite promising evidence for utilising dyadic interventions to increase PA (e.g., Prestwich et al., 2012), most of the PA literature has focused on individuals or groups. There has been no synthesis of the available research on dyadic PA interventions. Parenthood is a time of many external pressures which makes recruiting mothers and fathers to dyadic interventions challenging. Compelling evidence indicates that parents are less physically active compared to non-parents (Bellows-Riecken & Rhodes, 2008), and that it is the onset of parenthood that is particularly important for this decline in MVPA (Rhodes et al., 2014). Theories were discussed that helped to explain the dyadic relationship and goal pursuit. Alas, TGD theory does not incorporate the degree to which an individual's relationships with others helps that individual regulate their goals (Gore et al., 2018). For example, people may enjoy exercising because it

strengthens the relationship with their spouse or because their partner enjoys exercise. They might incorporate their partner's autonomous motivation in to their own reasons for goal pursuit (e.g., "my partner is happy when we run together, so seeing them smile makes me smile too"). Similarly, the goal literature (e.g., implementation intentions research) has primarily focused more on personal goals, "the I" (e.g., "if it's situation X then I will do Y") and less on interpersonal goals, "the we". This thesis therefore, moves beyond current perspectives of goal setting and focuses on utilising collaborative implementation intentions and motivational communication training with mothers and their significant other.

The studies in this thesis attempt to address research gaps by synthesising the research, focusing on fathers' PA as well as mothers, and exploring barriers to engagement in PA. Chapter 2 is the first systematic review and meta-analysis of dyadic interventions to promote PA. In line with the TGD theory (Fitzsimons et al., 2015), we investigated whether shared PA goals between dyad members were associated with larger effect sizes than non-shared goals. We also investigated the influence of different types of dyad relationships (e.g., parent-child, best friends, and romantic partners) that varied in their degree of transactive density. Chapter 3 focused on the implementation of a collaborative implementation intentions (c.f. Prestwich et al., 2012) and SDT-informed intervention targeting the PA of postpartum mothers and a study partner (e.g., the father of their child). Chapter 4 focused on an evaluation of this intervention using interviews with a subset of parents from the trial. This study is the first to combine implementation intentions with Self-Determination Training to promote PA of postpartum mothers and fathers. Finally, Chapter 5 presents a discussion of the results of the studies in this dissertation and their implications for the future of dyadic research. Utilizing a dyadic based approach to behaviour change is a promising research area, thus, we hope that our findings from these studies provide useful directions for future intervention research.

MY CONTRIBUTION

For the systematic review and meta-analysis (chapter 2), the PhD candidate conducted the systematic search. She decided on key elements of the studies to be extracted. She then completed data extraction and coded the studies in terms of risk of bias and defining characteristics (e.g., type of dyad, PA targeted, and goals etc…). She entered the data for the meta-analysis. For the PEEPS intervention (chapter 3), she was responsible for designing the

recruitment materials, recruiting parents, creating the intervention materials and website, delivering the workshops, and data entry. She designed the interview questions and conducted interviews (chapter 4) with parents and coded the transcripts using thematic analysis.

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CHAPTER TWO:

Dyadic Interventions to Promote Physical Activity and Reduce Sedentary Behaviour: Systematic Review and Meta-Analysis

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Abstract

Several interventions have targeted dyads to promote physical activity (PA) or reduce sedentary behaviour (SB), but the evidence has not been synthesised. Sixty-nine studies were identified from MEDLINE, PsycINFO, and Web of Science, and 59 were included in the main meta-analyses (providing 72 independent tests). Intervention details, type of dyadic goal, participant characteristics, and methodological quality were extracted and their impact on the overall effect size was examined. Sensitivity analyses tested effect robustness to (a) the effects of other statistically significant moderators; (b) outliers; (c) data included for participants who were not the main target of the intervention. Dyadic interventions had a small positive, highly heterogeneous, effect on PA g = .203, 95% CI [0.123–0.282], compared to comparison conditions including equivalent interventions targeting individuals. Shared target-oriented goals (where both dyad members hold the same PA goal for the main target of the intervention) and peer/friend dyads were associated with larger effect sizes across most analyses. Dyadic interventions produced a small homogeneous reduction in SB. Given dyadic interventions promote PA over-and-above equivalent interventions targeting individuals, these interventions should be more widespread. However, moderating factors such as the types of PA goal and dyad need to be considered to maximise effects.

Keywords: Randomised control trials, Dyads, Transactive Goal Dynamics Theory, Interventions; Systematic Review; Meta-Analyses

Regular Physical Activity (PA) is associated with reductions in the risk of chronic diseases (e.g. diabetes, overweight and obesity, bone and joint diseases, certain types of cancer) and improvements in mood and well-being (Craft & Perna, 2004; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010; Warburton, Nicol, & Bredin, 2006). There is also a positive association between Sedentary Behaviour (SB) (defined as sitting or lying down, except when sleeping; Department of Health, 2017b) and the risk of chronic disease and obesity (Department of Health, 2017a). Current public health recommendations specify that adults should achieve 150 minutes of moderate (e.g. walking) or 75 minutes of vigorous PA (e.g. running) per week (World Health Organization, 2010). SB guidelines suggest minimising the amount of time in prolonged sitting and breaking up long periods of sitting as often as possible (Department of Health, 2017b). However, worldwide 31.3% of adults have been classified as physically inactive (Hallal et al., 2012). Furthermore, 2 in 3 children and 5-17 year olds have 2 or more hours of screen-based entertainment every day (Department of Health, 2017a). The National Health Survey found that watching television was the most prevalent SB and, on average, adults watch close to 13 hours of television per week, peaking at 19 or more hours per week for people aged 75 and over (Department of Health, 2017a). Interventions aimed at fostering and sustaining adequate levels of PA, as well as reducing SB, are thus key public health priorities.

Individuals often attempt to change their health behaviours, such as PA and SB (or refrain from doing so), while being embedded in social networks comprising, amongst others, friends, romantic partners, and family (Scholz & Berli, 2014). However, interventions to promote PA and/or reduce SB are typically focused on individuals or groups. Given that there is both theoretical (e.g. Lewis et al., 2006) and empirical evidence (e.g. Arden-Close & McGrath, 2017) highlighting the role of others in influencing an individual's behaviour, including their level of PA, there is a need to consider, systematically, the potential impact of dyadic interventions to promote PA and reduce SB.

Dyads are defined as two individuals (such as husband and wife, or two friends) maintaining a socially significant relationship ("Dyad," n.d.). Although there are several group-based interventions to promote PA (e.g. Leahey et al., 2010; Leahey, Kumar, Weinberg, & Wing, 2012), only a subset of these target dyads. There has been some evidence suggesting that interventions targeting the promotion of PA through dyads can be effective (e.g. Castro, Pruitt, Buman, & King, 2011; Prestwich et al., 2012; Winters-Stone et al., 2016). However, other randomised controlled trials indicate that dyadic-based interventions have little influence on PA (Boutelle, Norman, Rock, Rhee, Crow, 2013; Brown et

al., 2015; Burke et al., 1999). One potential reason for the inconsistency of these findings is that the nature of the dyadic intervention, and in particular the goals held by each member of the dyad, can vary across interventions. Our review addresses this possibility by systematically categorising and synthesising the different types of PA goals and their effects on PA levels. In addition, studies have flagged the impact that dyadic relations can have on sedentariness. For example, data from 431 parent child dyads shows that parents can have a significant influence on the amount of television viewed by their children (Jago et al., 2011) and that mother's SB is strongly associated with father's SB (Wood, Jago, Sebire, Zahra, & Thompson, 2015). This has led to calls for and applications of dyadic interventions to reduce SB (e.g. Ostbye et al., 2012), but there has been no synthesis of the available empirical evidence. There is some evidence from two family-based treatments that targeting dyads can be effective in reducing SB (Epstein, Paluch, Kilanowski, & Raynor, 2004). However, there was little effect on SB from a randomised controlled trial (see Ostbye et al., 2012).

Transactive Goal Dynamics Theory

Numerous theoretical approaches have been applied to dyadic interventions (see Table A1, Supplementary Materials 1). However, none of the applied theoretical approaches were developed explicitly for dyads. In this review we use the Transactive Goal Dynamics theory (TGD), which; Fitzsimons, Finkel, and vanDellen (2015), applied specifically to dyads. Alas, this theory can be used to explain the types and processes by which PA and SB goals in dyad members are set and pursued. As such, it provides a useful framework within which to synthesise the existing literature.

TGD theory adopts a relational perspective on "self-regulation". Rather than conceptualising a given pair of individuals as two independent self-regulating agents, the theory identifies the dyad as the regulating unit, with the partners as subunits of a single system of goal dynamics, a system in which resources are shared. According to TGD, dyadic goal pursuit should become more effective with increasing levels of transactive density (the extent to which the dyad members' goals, pursuits and outcomes are linked) as long as there is sufficient goal coordination (the extent to which the dyad members' goal pursuits facilitate each other). For example, if one dyad member is aiming to run a marathon and their partner wants to lose weight, these goals are linked (thus they have high transactive density) and the dyad members can run together to fulfil both their goals (good goal coordination). Fitzsimons et al. (2015) identified seven types of dyadic goals: (1) shared system-oriented goals (both members have the same goal for their own and for their partner's outcomes; for example, if the goal is to increase PA, both dyad members want for themselves and for each other to increase their PA); (2)

shared target-oriented goals (both dyad members have the same goal for one person in the dyad); (3) system-oriented goals (one dyad member has the same goal for their own and their partner's outcomes); (4) parallel self-oriented goals (both dyad members have the same goal for themselves); (5) parallel partner-oriented goals (both dyad members have the same goal for their partner's outcomes); (6) partner-oriented goals (one dyad member has a goal for their partner, their partner does not have a goal for themselves); (7) self-oriented goals (one dyad member has a goal for themselves).

According to the TGD theory, dyads sharing goals for the same target dyad member (shared system-oriented and shared target-oriented goals) should have a smooth division of goal-related effort, because both dyad members should be motivated to maximise goal-related outcomes, and thus, they are more likely to effectively divide goal-related effort. Coordination is easier when dyads agree about the desired outcomes for each partner. In line with TGD theory, interventions that encourage dyads to create shared system-oriented and shared target-oriented type-goals should be more effective in increasing PA than interventions that encourage dyads to create parallel self-oriented, parallel partner-oriented, system-oriented, partner-oriented, or self-oriented type-goals.

TGD theory also indicates that the extent to which dyads are dedicated to the relationship can also influence goal coordination, with stronger dedication enhancing goal coordination. Given that under high levels of goal coordination transactive density improves goal outcomes (Fitzsimons et al., 2015), stronger relationship dedication should also increase goal outcomes. According to the TGD theory, a dense transactive system (e.g. developed after many years of marriage), results in the dyad's goals and pursuits being interdependent. In such a system, there are diverse, frequent, and strong effects of dyads on each individual's goals, pursuits, and outcomes. Thus, interventions that target dyads with a strong bond, that is a dense transactive system (e.g. close family members, very close friends), are more likely to be effective than dyads with a weaker bond (e.g. work colleagues), as long as goal coordination is sufficient. In corroboration of this hypothesis, there is evidence suggesting that a person's PA is associated with close others (i.e. their romantic partners and best friend's) PA though this relation may vary depending on perceived support (Darlow & Xu, 2011). Such evidence is in line with research showing that health behaviours are concordant across couples (Arden-Close & McGrath, 2017) and if a partner adopts a healthier behaviour, the other partner is more likely to make a positive health behaviour change (Jackson, Steptoe, & Wardle, 2015).

The Present Review

The overarching goal of this study was to conduct the first systematic review and meta-analysis of dyadic interventions aiming to increase PA via a randomised controlled trial design on PA and SB outcomes. We tested the effect of dyadic interventions against different types of control conditions including, importantly, interventions utilising the same behaviour change techniques (Michie et al., 2011) but focusing on individuals as opposed to dyads. We also examined the type of goals manipulated within the intervention (using TGD theory to categorise such goals) as well as the type of relationship between the dyad members. In keeping with the basic tenets of TGD, we hypothesised that: (1) dyadic interventions would increase PA and reduce SB more than non-dyadic interventions; (2) dyadic interventions will be most effective if dyads have the same goal for the same target dyad member (shared system-oriented and shared target-oriented goals); and (3) dyadic interventions targeting dyads with a close bond (e.g. long-term partners, close friends) would yield larger effects than interventions targeting dyads with weaker bonds (e.g. participants assigned a role model). There is a risk that the effects of seemingly important moderators may be confounded (Peters, de Bruin, & Crutzen, 2015), thus we adopted an approach used in recent reviews (e.g. Caperon et al., in press; Prestwich et al., 2014, 2016) to address this issue. Specifically, the robustness of these moderator effects was examined via a series of sensitivity analyses which (a) controlled for the effect of any other moderator significantly influencing the overall effect size; (b) removed study outliers; and (c) combined the effect sizes for the participants who were the main target of the intervention with the effect sizes for their study partner (if available).

Method

We conducted a systematic search across three databases MEDLINE, PsycINFO, and Web of Science (limited to studies published from 1996 onwards as that was the earliest date available in the Medline database). The review protocol was published in the International Prospective Register of Systematic Reviews, and can be accessed from http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016038231.

Inclusion and Exclusion Criteria

Patient, population or problem. Studies were included if they tested a dyadic intervention to increase PA. Studies were excluded if one member of the dyad was a health professional instructing the other member. There were no restrictions on the age of the participants, setting, or location of the study.

Intervention or exposure. Studies were included if they randomised participants to an experimental group or a control group. Systematic reviews of randomised trials are the 'gold standard' for judging whether a treatment does more good than harm (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996).

Comparison. The only restriction was that the comparison could not be an equivalent dyadic intervention aimed at PA promotion. Dyadic interventions in which the comparison group(s) were allocated to another dyadic intervention (not focused on PA) were included.

Outcome. Studies were included if they assessed PA post-intervention. Studies which measured SB in addition to PA were also included. Studies were excluded if relevant PA outcome data were not reported for the target individuals in the dyad and corresponding authors did not respond to two requests for further information. If studies did report outcome data but did not report relevant statistical information to calculate effect sizes, they were included in the qualitative synthesis but not in the meta-analysis. The included studies had to have a quantitative methodology.

Studies were only included if they were published in the English language.

Search Strategy

A search strategy was developed, with three groups of search terms based around (a) randomised controlled trials (Baker, Francis, Soares, Weightman, & Foster, 2015); (b) dyads (Brandão, Schulz, & Matos, 2014; Park, Tudiver, & Campbell, 2012); and c) PA (Baker et al., 2015); see Supplementary Material 2. The search was conducted by the lead author between 26 May 2016 and 2 June 2016 and updated on 7 December 2017. Additional studies were identified via searches of reference lists of included studies and from reading journal articles. The 'grey' literature search included contacting the corresponding authors of included studies for any unpublished data on the same topic (no additional studies were identified) and through locating full texts of dissertation abstracts listed in the databases (six additional studies were found).

Data Extraction

The type of dyad for each study was coded into 6 different types – parent and child, peers/friends, romantic couples, participant and any significant other (i.e. no set criteria for who that significant other had to be), participant and a personal carer, or participant and a confederate. The types of goals were coded according to the TGD theory. As none of the goals reported in the studies were explicitly categorised using the TGD framework, two coders reached a consensus

on which types of goals were employed based on the information presented in the text. For instance, when the text suggested that both dyad members had the same goal but they were not interdependent and each partner was not requested to support the other, the type of goal was coded as 'parallel self-oriented'. Both the type of dyad and type of goals analyses were pre-specified in the review protocol. The major theory underpinning each study, the type of control group, duration of intervention delivery and follow-up, type of PA – strength, walking, bike or any activity (i.e. no mention of a specific PA), were coded for each study. Some samples engaged in more than one type of exercise (e.g. aerobic-strength) and were allocated into a 'combined PA' group. Measures of physical functioning (e.g. difficulties in bathing/showering), mobility (e.g. gait), fitness (e.g. $\dot{V}O_{2max}$) and light PA were not coded. SB (e.g. time spent watching screens/sitting) was included as a secondary outcome measure.

Two raters judged the methodological quality of the included studies as either high/unclear (1) or low bias (2) on seven dimensions of bias (Higgins et al., 2011; see Figure A1, Supplementary Materials 3). Studies rated as having 'high' or 'unclear' bias were combined into one category and then compared with the 'low' category, as described in the Cochrane Collaboration guidelines (Higgins & Green, 2011). A random number generator was utilised to select 40% of the studies (24 studies) from the initial search for double coding for the risk of bias (non-blind). Following the example of Kwasnicka, Presseau, White, and Sniehotta (2013), the first 20% of coding was deemed appropriate as a test round to operationalise and check consistency in applying the criteria. Following the test round, agreement between two coders on the next 20% of studies was almost perfect (Cohen's Kappa = .82). With regard to the coding of moderators, the moderators of the type of goal and type of dyad were double-coded by a second reviewer (who was not blinded to the first author's judgements), as we had specific hypotheses for those and they were of central focus to the study. All other moderators were coded by one reviewer.

Meta-Analysis Strategy

Effect sizes (Hedges's *g*) for a random-effects model were calculated for each study using the Comprehensive Meta-Analysis Software (Version 3; Borenstein, Hedges, Higgins, & Rothstein, 2015). Wherever possible, the effect sizes were calculated based on the post-baseline means and standard deviations rather than scores reflecting change from baseline to follow-up, as the latter are not independent of each other (Cuijpers, Weitz, Cristea, & Twisk, 2017). When

authors did not report analyses accounting for clustering either within the dyad or within larger clusters (i.e. within cluster randomised controlled trials), corrections were applied by calculating effective sample sizes (when effect sizes were based on means and standard deviations or proportions) or inflating standard errors of the effect sizes (e.g. when effect sizes were based on *p*-values) based on the larger cluster (see Higgins & Green, 2011). The moderator analyses were conducted using meta-regression in STATA (Version 13.1; Statacorp, 2013). The I^2 statistic was used to describe the percentage of variation across studies attributable to heterogeneity rather than chance.

Dealing with multiple intervention groups. If studies included multiple dyadic interventions for PA, all such interventions were included in the analysis. To ensure independence of participants, the number of intervention group participants was divided by the number of interventions (Borenstein, Hedges, Higgins, & Rothstein 2009). This method was also applied when two comparison groups (e.g. an individual-level intervention and a standard control group) were included in the same study.

Sensitivity Analyses. Sensitivity analyses were conducted to establish the degree to which the key findings were robust when (a) significant moderators were co-varied; (b) outliers were removed; and (c) data were included for participants who were not the main target of the intervention. The Sample-Adjusted Meta-analysis Deviance (SAMD) statistic (Huffcut & Arthur, 1995) was calculated to produce a scree plot which was used to detect outlier studies. Egger, Smith, Schneider, and Minder's (1997) test of funnel plot asymmetry and trim and fill analyses assessed publication bias.

Results

In total, 14,532 studies were identified via the search terms, of which 413 were full-text screened. Of these, 69 studies were eligible, with 65 studies initially included in the meta-analysis (k = 82 comparisons, see Figure 1). Throughout this paper k refers to the number of comparisons. The studies by Boutelle et al. (2013), Holthoff et al. (2015) and Tymms et al. (2016) were not meta-analyzed, as they did not provide sufficient statistical information to allow their inclusion. The study by Gunnarsdottir, Sigurdardottir, Njardvik, Olafsdottir, and Bjarnason (2011) was not meta-analyzed as the authors pooled data from two independent groups to increase statistical power and we did not have the data from each group.

Of the 65 included studies, 16 targeted participants with a current or previous health issue, such as significant cardiac event (Sher et al., 2014), osteoarthritic knee pain (Keefe et al., 2004), breast cancer (Demark-Wahnefried et al., 2014), stroke (Kim, Lee, & Kim, 2013) or any type of cancer except squamous or basal cell skin cancers (Kamen et al., 2016); the other 49 studies targeted participants without any history of significant illness. Forty-four studies targeted healthy weight participants and 21 studies recruited overweight or obese participants. The majority of comparisons (k = 38) targeted parent-child dyads and were conducted in the USA (k = 54). The most common type of comparison group comprised of no-intervention or minimal intervention (e.g. received a book/newsletter; k = 26). The median intervention duration of the 65 studies was 84 days, hence, intervention duration of 84 days or longer was classified as "longer", whereas duration of less than 84 days was deemed as "shorter". The majority of studies had low risk of bias relating to random sequence generation (62%) and incomplete outcome data (83%). Most studies had high or unclear risk of bias pertaining to lack of: allocation concealment (72%), blinding of participants and personnel (97%), blinding of outcome assessors (68%), selective outcome reporting (71%), and other risks of bias (60%) (see Figure A1, Supplementary Materials 3).

Effects of Dyadic Interventions on PA and SB

Comparisons that included a confederate within the dyad for the experimental group (an actor playing the role of an exercise partner) (k = 10, g = 1.05) produced much larger effect sizes than comparisons that did not use a confederate in the experimental group (k = 72, g = 0.20), B = 0.84, SE = 0.13, t = 6.53, p < .001. The confederate and non-confederate studies were fundamentally different with 5 out of 6 (representing 9 of 10 comparisons) of the former being lab-based studies, and all 6 testing the Köhler effect (i.e. how the presence of a superior partner may increase motivation to exercise). Given the confederate studies also yielded generally homogeneous effect sizes I^2 = 31.8%, $\chi^2(9)$ = 13.19, p = .15, the 10 confederate comparisons were excluded from all the analyses henceforth.

Following removal of the confederate studies, dyadic interventions were found to have a small positive effect on PA, relative to control groups, g = 0.20, 95% CI [0.12 – 0.28], K = 72 comparisons (see Figure 2). However, there was significant heterogeneity, I^2 = 61.5%, $\chi^2(71)$ = 184.20, p < .001, which was further examined (see moderator analyses).

Dyadic interventions targeting PA outperformed comparison conditions which: (a) comprised the same intervention techniques but targeted individuals, $g = .17$, $k = 13$, $p = .01$, or (b) reflected usual care, $g = .32$, $k = 26$, $p < .001$. Dyadic interventions targeting PA performed marginally better (but the effect was not statistically significant) than comparison groups which were dyadic but not directed at PA, $g = .13$, $k = 14$, $p = .09$. This effect was similar when an extra comparison was added (Spouse assisted pain coping skills training + exercise vs. Spouse assisted pain coping skills training from Keefe et al. 2004, which was omitted from the main analyses because it only reported sufficient statistics to accurately calculate effect sizes for 2 out of 3 outcomes; the effect size for the third outcome was conservatively estimated as $g = 0$), $g = .15$, $k = 15$, $p = .05$. Dyadic interventions were not meaningfully different from waiting list, $g = .09$, $k = 16$, $p = .17$, or miscellaneous, $g = .06$, $k = 3$, $p = .61$, comparison conditions.

Dyadic interventions also had a small positive effect, relative to comparison conditions, on reducing SB (total SB and TV viewing), $g = .19$, 95% CI [0.10 - 0.28], $k = 20$. Dyadic interventions outperformed waiting list, $g = .22$, $k = 7$, $p = .049$, and usual care, $g = .16$, $k = 8$, $p = .006$, comparison groups. Dyadic interventions did not outperform dyadic interventions not directed at PA, $g = .22$, $k = 4$, $p = .17$ or equivalent interventions targeting individuals, $g = .23$, $k = 1$, $p = .17$, but the number of datasets for such comparisons was small. As a consequence, such findings should be interpreted with caution and require more studies for a more precise estimate of the effect sizes. Given the overall effect of dyadic interventions on SB was homogeneous, $I^2 = 19.4\%$, $\chi^2(19) = 23.56$, $p = .21$, no further moderator analyses were conducted for this outcome.

Moderator Analyses

Type of goals. As shown in Table 1, shared target-oriented goals were associated with significantly larger PA effect sizes than studies which manipulated other types of goals. Goals which were shared system-oriented, system-oriented, partner-oriented or parallel self-oriented, yielded similar effect sizes. Parallel partner-oriented goals and self-oriented goals were not manipulated in any dyadic intervention condition.

Type of dyad. In the main analyses, the effect sizes did not significantly vary depending as a function of the type of dyad. Specifically, comparisons that were based on parents and child dyads, couples, participants and their carer/caregiver, or participants and a significant other yielded similar effect sizes. Utilising Cafri, Kromfey, and Brannick's (2009) SAS macro we estimated the power for the type of dyad comparison to be .94. This gives more reliability to our

null findings, as high power reduces the probability of accepting a type II error (i.e. accepting a false negative result). Effect sizes were marginally larger when based on peers/friends and significantly larger in several of the sensitivity analyses.

Other moderators. Studies that targeted clinical samples, conducted outside Australia/New Zealand, UK, Germany, US and Canada (labelled as 'other countries' and comprised of studies conducted in Sri Lanka, Israel, Mexico, Korea and Iran, Switzerland, Sweden, Ireland, Finland and the Netherlands), as well as studies that utilised a usual care control group, were associated with larger effects. Studies that assessed PA using objective measures only were associated with smaller effects, as were studies that had a non-blinded outcome assessor or did not specify if this blinding occurred. None of the other moderators were significantly associated with PA effect sizes (see Table 1).

Table 1
Meta-Regressions Showing Moderators of the Effect of Dyadic Interventions on PA

	Main target (*K*= 72)[a] 95% CI						Main target & support[b] (*K*= 72)	OUTLIERS REMOVED 1Extreme (*k* = 71)	2 removed (*k* = 70)	5 removed (*k* = 67)
	k (present)	*k* (absent)	*B*	Lower limit	Upper limit	*p*	*p*	*p*-values		
Type of dyad										
Parent and child (38) vs. others (34)	38	34	-0.05	-0.22	0.12	.58	.64	.24	.30	.07
Couples (13) vs. others (59)	13	59	-0.09	-0.30	0.13	.43	.43	.59	.63	.65
Participants and a carer (5) vs others (67)	5	67	0.09	-0.29	0.48	.62	.61	.68	.90	.87
Peers/ friends (8) vs. others (64)	8	64	0.27	-0.01	0.55	.06	.05*	.01**	.004**	*p*<.001***
Participant + significant other (8) vs. others (64)	8	64	-0.03	-0.30	0.23	.80	.66	.91	.93	.47
Type of goals										
Shared system-oriented (22) vs others (50)	22	50	-0.10	-0.28	0.09	.30	.23	.40	.43	.91
System-oriented (13) vs other (59)	13	59	-0.09	-0.31	0.12	.40	.43	.43	.45	.42
Shared target-oriented (19) vs others (53)	19	53	0.27	0.09	0.45	.003**	.003**	.01*	.01*	.07
Partner-oriented (10) vs others (62)	10	62	-0.11	-0.34	0.13	.38	.37	.43	.45	.42
Parallel self-oriented goals (4) vs others (68)	4	68	-0.02	-0.42	0.38	.92	.95	.89	.86	.83
New type. System and parallel self (6) vs others (66)	6	66	-0.13	-0.46	0.21	.45	.48	.64	.66	.70
Control group										
Other-dyadic (14) vs others (58)	14	58	-0.09	-0.30	0.12	.41	.36	.57	.60	.96
Individual (13) vs others (59)	13	59	-0.06	-0.30	0.17	.58	.63	.96	.99	.89
Waiting list (16) vs others (56)	16	56	-0.10	-0.32	0.13	.39	.30	.48	.50	.64
Usual care (26) vs others (46)	26	46	0.18	0.01	0.35	.04*	.03*	.15	.19	.51
Miscellaneous (3) vs others (69)	3	69	-0.11	-0.48	0.26	.54	.63	.44	.44	.37
Type of PA										
Any (65) vs. specific PA (7)	65	7	-0.19	-0.50	0.12	.22	.57	.15	.14	.14
Strength (4) vs others (68)	4	68	0.35	-0.10	0.80	.13	.12	.06	.05	.04
Walking (1) vs others (71)	1	71	-0.19	-0.79	0.41	.52	.53	.48	.48	.45
Mixed (2) vs others (70)	2	70	0.24	-0.28	0.76	.37	.91	.23	.21	.19
Method of measurement of PA										
Objective (yes= 23; no= 49)	23	49	-0.23	-0.40	-0.05	.01*	.03*	.01**	.01**	.01**
Self-report (yes= 45; no= 27)	45	27	0.13	-0.04	0.31	.14	.17	.16	.17	.18
Both (yes= 4; no= 68)	4	68	0.32	-0.05	0.69	.09	.27	.02*	.02*	.01*
Mode of delivery to the intervention group										
Face-to-face (yes= 53; no= 19)	53	19	-0.02	-0.23	0.18	.82	.85	.69	.88	.92
Written/printed (yes= 36; no= 36)	36	36	-0.11	-0.27	0.06	.21	.19	.29	.32	.54
Telephone (yes= 25; no= 47)	25	47	0.00	-0.17	0.18	.98	.96	.72	.83	.49

Online/PC (yes= 10; no= 62)	10	62	0.00	-0.25	0.26	.97	.99	.97	.78	.76
Video (yes= 10; no= 62)	10	62	-0.06	-0.31	0.20	.66	.84	.32	.17	.34
Duration of delivery										
Longer duration (longer= 41; shorter= 31)	41	31	0.11	-0.06	0.28	.19	.26	.26	.19	.16
Number of sessions										
Multiple session (yes= 59; no= 13)	59	13	-0.00	-0.23	0.23	.999	.93	.91	.87	.90
Assessment periods compared										
From baseline or the start to the follow-ups	n/a	n/a	0.00	-0.00	0.00	.61	.54	.59	.51	.47
From end of intervention to the follow-ups	n/a	n/a	-0.00	-0.00	0.00	.46	.57	.46	.46	.48
Clinical population or non-clinical population										
Clinical (yes= 17; no= 55)	17	55	0.22	0.02	0.42	.04*	.05*	.01**	.01*	.01**
The participants were overweight/obese†										
Overweight/obese (yes= 25; no= 47)	25	47	0.02	-0.16	0.20	.84	.95	.46	.51	.51
ROB: randomisation										
High/unclear (25); low (47)	25	47	0.10	-0.08	0.28	.27	.25	.04*	.03*	.12
ROB: allocation concealment										
High/unclear (49); low (23)	49	23	0.07	-0.11	0.25	.45	.46	.63	.67	.80
ROB: blinding of participants and personnel										
High/unclear (70); low (2)	70	2	-0.12	-0.59	0.35	.61	.59	.63	.61	.66
ROB: blinding of outcome assessors										
High/unclear (46); low (26)	46	26	-0.20	-0.37	-0.03	.02*	.03*	.04*	.03*	.01**
ROB: incomplete outcome data										
High/unclear (12); low (60)	12	60	-0.07	-0.32	0.18	.58	.42	.58	.59	.53
ROB: selective outcome reporting										
High/unclear (48); low (24)	48	24	-0.05	-0.23	0.13	.59	.60	.12	.09	.08
ROB: other bias										
High/unclear (41); low (31)	41	31	0.05	-0.12	0.23	.53	.57	.15	.18	.47
Setting of the study										
Australia/New Zealand (yes= 9; no= 63)	9	63	-0.14	-0.40	0.12	.28	.32	.20	.20	.16
UK/ Germany (yes= 9; no= 63)	9	63	-0.12	-0.36	0.13	.34	.43	.37	.38	.36
USA/ Canada (yes= 44; no= 28)	44	28	-0.04	-0.22	0.13	.62	.48	.71	.61	.20
Other (yes= 10; no= 62)	10	62	0.27	0.05	0.48	.02*	.01*	.17	.24	.71

Note. *p<.05, **p<.01, ***p<.001, MOD: Mode of delivery. ROB: Risk of bias † Studies where either one or both dyad members had to be overweight were compared to studies where there were no *apriori* criteria for the dyad members to be overweight [a] Main target = the dyad member who was the focus of the intervention; if both dyad members were targeted equally, both were included as the main target, [b] Including data from the participant's dyad partner who supports them to increase PA. For the new type: System = system-oriented, Parallel self = parallel self-oriented.

Sensitivity Analyses

Controlling for the effect of other significant moderators. Shared target-oriented goals produced marginally larger effects than dyadic interventions using other types of goals from the TGD theory, even after controlling for the effects of other statistically significant moderators in a multivariate meta-regression (see Table A3, Supplementary materials 4). Studies that utilised shared target-oriented goals were more likely to be conducted outside the UK, Germany, Australia, New Zealand, United States, and Canada, $\chi^2(1) = 11.37$, Fisher's $p = .002$, and to be used within a greater proportion of studies targeting clinical populations, $\chi^2(1) = 8.08$, Fisher's $p = .01$. A second multivariate meta-regression that co-varied only these 2 potential confounders resulted in a similar effect. Specifically, studies using shared target-oriented goals produced marginally larger effects than studies that used other types of goals (see Table A4, Supplementary materials 4).

Outliers. Based on the scree-plot (see Figure 3), there was clearly 1 extreme outlier. However, it was not clear whether there were 0, 1 or 4 additional outliers (i.e. 1, 2 or 5 outliers in total). Thus, we examined the impact of removing outliers under these three scenarios (see Table 1). Across these 3 scenarios, the results were largely unchanged. In particular, shared target-oriented goals significantly increased effect sizes when the single extreme outlier was removed and when 2 outliers were removed (they marginally increased effect sizes when 5 outliers were removed). Studies that targeted peer/friends produced larger effects than studies targeting different types of dyad across all outlier analyses.

Data based on participants not targeted for behaviour change. The original analysis was based on the effect sizes for participants who were the main target of the intervention (in some instances, both members of the dyad were targeted equally). However, ten studies also reported data regarding the participants partners' levels of PA, despite them not being the main target of the intervention. When the analyses were conducted including these additional data and comparing the new results to the original effect sizes the results from the moderator analyses remained largely unchanged. Aside from dyadic interventions targeting peers/friends now yielding significantly larger effects, the other non-significant moderators remained non-significant and all of the significant moderators remained significant.

Tests for publication bias. A funnel plot was employed to test for publication bias (see Figure 4). The funnel plot appears only somewhat symmetrical on visual inspection, and the

effect sizes from studies with larger standard errors appear only slightly more scattered than for studies with more precise estimates of effect size. However, funnel plots can be interpreted differently by different observers (Villar, Piaggio, Carroli, & Donner, 1997). Consequently, Egger et al.'s (1997) test of funnel plot asymmetry was conducted and indicated a modest risk of publication bias, *Intercept B0* = 0.89, 95% CI [0.08 – 1.71], p = .03. However, trim and fill analysis suggested that the effect of dyadic interventions on PA remained significant when accounting for 'missing studies', g = 0.14, 95% CI [0.04 - 0.23]. In addition, studies reported within dissertations generated similar sized effects compared to studies published in peer reviewed journals B = 0.02, p = .93.

Discussion

The overarching goal of this study was, for the first time, to systematically review and meta-analyse dyadic randomised controlled interventions aiming to increase PA or reduce SB. Sixty nine randomised controlled trials were eligible, with 59 studies included in the final set of meta-analyses generating 72 comparisons. Drawing from the TGD theory (Fitzsimons et al., 2015), we hypothesised that people allocated to dyadic interventions aiming to improve PA will increase PA significantly more than participants not in a dyadic intervention, with similar effects on reducing SB. We found some support for these predictions in that dyadic interventions had on average a small positive effect on PA, and a similar sized, but homogeneous, effect in reducing total SB and TV viewing. Importantly, dyadic interventions outperformed interventions that targeted an individual when these conditions were otherwise matched. In addition, studies testing dyadic interventions targeting clinical populations generated larger effect sizes than studies testing dyadic interventions targeting non-clinical populations.

With regard to the type of goal, although it was predicted that shared goals (shared system-oriented and shared target-oriented) would generate larger effects than non-shared goals, only shared target-oriented goals produced larger effect sizes, compared to non-shared target-oriented goals. This comparison remained significant even after controlling for other significant moderators. This finding was surprising as it was anticipated that these types of goals would be equally beneficial. Our expectation was based on the hypothesis that dyads sharing goals for the same target should facilitate smooth division of goal-related effort as both parties should be motivated to maximise outcomes, and thus, would be more likely to divide the task effectively. However, it appears that setting goals for both partners to increase PA may not always be

effective. Possible reasons for this finding are that generating these types of goals may reduce the number of appropriate opportunities to act, or there may be more barriers to performing these activities together rather than alone, or the reason (e.g. a medical necessity) for increasing PA may only apply to one partner (see Benyamini, Ashery, & Shiloh, 2011; Burkert, Scholz, Gralla, Roigas, & Knoll, 2011; Knoll et al., 2017).

As well as proposing that the type of goal could influence dyadic outcomes, the TGD theory also indicates that the type of dyad could also be a contributing factor. It has been suggested by Fitzsimons et al. (2015) that dyads which have a close bond/ high transactive density (e.g. couples) have diverse, frequent, and strong effects on each other's goals, pursuits, and outcomes. Whether these strong effects are positive or negative on goal success is dependent on the level of goal coordination, which itself is influenced by the type of goal and goal responsiveness (Fitzsimons & Finkel, in press). Goal responsiveness is higher when partners provide the appropriate level of support (i.e. high support when in need; low support when there is low need) and when the support is not interpreted as pressurising (cf. Fitzsimons & Finkel, in press). Perceptions of being pressured could be more likely in transactively dense relationships, especially if they are asymmetric (e.g. parents-child). On the basis that transactively dense relationships can promote goal success but also be hindering (e.g. in cases where goal responsiveness is inadequate), it is perhaps not surprising that many of the types of dyads produced similar effects. The exception was peer/friend dyads which yielded larger effect sizes than other types of dyad. It may be that peers/friends, at least in the context of PA, combine both the positive effects of relatively high interdependence with high levels of goal responsiveness. Indeed, sociocultural and communication theories suggest people are more receptive to assistance when it is delivered by someone of a similar age and background (see Castro et al., 2011). Nevertheless, further research is needed to directly measure or manipulate all of these constructs (interdependence, goal coordination, type of goal and goal responsiveness) to establish their direct, moderating, and mediating roles in achieving goal success. In the present review, we only measured the type of goal and inferred interdependence (and varying levels of relationship commitment which can influence goal coordination, see Tenet 4, Fitzsimons et al., 2015) based on the type of dyad. We assumed that opportunity and motivation (the two key determinants of transactive density, Fitzsimons & Finkel, in press), as well as relationship

commitment, were likely to be higher for certain dyads (e.g. romantic couples) than others (e.g. work colleagues).

With regard to romantic couples, there was no main effect on effect sizes (i.e. the magnitude of effects of PA interventions targeting couples were similar in size as those targeting other types of dyads). Perhaps in shorter periods of cohabitation, couples pursue more solo activities and/or their goals are less well co-ordinated and thus, benefit equally from individually tailored interventions as they do from dyadic interventions. As only 13 comparisons in the main analysis involved couple dyads, with little variation in their cohabitation history, we did not test this hypothesis as a moderator. Future studies could explore whether length of cohabitation influences the choice and effectiveness of different types of couples-based interventions for PA promotion.

Regarding the larger effect sizes in studies targeting peer and friend dyads than studies targeting different types of dyad, it should be noted that only six studies (yielding 8 comparisons) targeted peers or friends. In a relatively high proportion of these studies, participants were allocated a PA role model/mentor and the participants were in their mid-50s (Pinto, Stein, & Dunsiger, 2015; Ungar, Sieverding, Weidner, Ulrich, & Wiskemann, 2016) or over 50 years old (Castro et al., 2011). It could be that older participants benefit more from being allocated an exercise partner or mentor; however, this hypothesis warrants further investigation. An alternative explanation is that, as 3 out of the 8 comparisons involved participants setting shared target-oriented goals, the beneficial effects of the peer/friend dyad might have been confounded with the finding that shared target-oriented goals are more effective than non-shared goals. Regarding the larger effect sizes in studies targeting dyads from clinical populations than studies targeting dyads from non-clinical populations, this seems to be consistent with TGD. In such populations, where there is a clinical need for change, one may expect strong commitment to the PA goal for both dyadic members and, hence, strong goal coordination (see Tenet 4 of the TGD, Fitzsimons et al., 2015) which aids goal success.

It should be noted that six comparisons involved a type of goal which did not fit into any of the TGD categories. The related studies involved one dyad member having a goal for their partner to increase PA, while their partner was aiming to increase their own PA, but not the activity of the other dyad member. There were no differences in effect sizes between this discordant type of dyadic goal and the other types of goals.

There are several ethical and methodological issues to consider when designing and testing dyadic interventions. First, several studies in our review involved asymmetric relationships (e.g. parent-child, participants and a carer) raising issues as to whether both dyad members were equally motivated and engaged in the intervention. While ensuring high goal responsiveness is important, in line with TGD (Fitzsimons et al., 2015; Fitzsimons & Finkel, in press), it is also important to promote amongst both members of a dyad self-determined (autonomous) motivation for activity engagement, by fostering the three needs of autonomy (having choice and pursuing activities that suit one's values), competence (being able to achieve mastery) and relatedness (feeling connected to other people) (Ryan & Deci, 2000). Second, dyads are non-independent. Indeed, health behaviours are concordant across couples (Arden-Close & McGrath, 2017; Jackson et al., 2015). Consequently, analysing the PA or SB data of one dyad member should account for this non-independence and also for partner's activity. The actor-partner interdependence model (Cook & Kenny, 2005) retains the individual scores of participants, while treating them as being nested in a dyad. This allows for the estimation of both individual and dyadic factors, taking into consideration that each person influences the other. Such analysis should be used wherever possible in dyadic research. However, none of the studies in our review used this approach. We attempted to account for clustering following Cochrane guidelines although there appears to be no definitive rule as how to adjust for clustering in dyadic interventions. Thus, there may be alternatives to our approach.

Limitations and Future Research Directions

There are a number of potential limitations that need to be acknowledged. First, there is a possibility that studies that should have been included in the review were omitted. Several attempts were made to minimise this risk, including generating broad search terms based on previous reviews, and utilising multiple databases, including dissertations. Second, there is a risk that there were coding errors. To minimise this risk, key elements of the data extraction (including effect size calculations) were double-checked by second coders. Third, given the results of the Egger et al.'s test and trim and fill analyses, it is not possible for us to rule out the possibility of publication bias. However, while the results of these analyses *estimate* the likelihood of publication bias and its impact, there is some evidence supporting the possibility of no publication bias: (1) there were no differences in effect sizes between studies reported in dissertation versus journal articles; and (2) we contacted all corresponding authors of included

studies and none stated that they had any unpublished studies meeting the eligibility criteria. There may be differences (e.g. in terms of statistical significance or direction of group differences) between the data/studies that authors are willing to share and those studies for which authors are not willing to share (see Prestwich et al., 2017). Pre-registering of protocols and subsequent publication regardless of result is thus particularly warranted in future research. Fourth, we did not code the behaviour change techniques (Michie et al., 2011) used in the included studies. Future studies should explore whether certain behaviour change techniques e.g. goal-setting (behaviour) are more effective when used amongst different types of dyads who pursue different types of goals. Further research should also directly compare interventions with shared target-oriented goals and interventions with shared system-oriented goals and identify the reasons why such interventions may differ in terms of their impacts on behaviour. While studies have compared dyadic interventions targeting PA against equivalent interventions targeting individuals, we are unaware of any studies that compare dyadic PA interventions against equivalent PA interventions targeting larger groups (i.e, more than 2 members). Finally, only 16 studies provided separate data on SB that could be included in the meta-analysis, thus there is scope for more empirical research in this area. The number of studies for each moderator comparison was small, such findings, particularly those for SB, should be interpreted with caution and require more studies for a more precise estimate of the effect sizes. Our review focused on dyadic interventions that aimed to promote PA, and in some cases, to reduce SB. Future interventions could utilise a dyadic design focusing on SB only and testing the effects of different strategies to reduce it (Manini et al., 2015).

Study Implications and Conclusions

We found that dyadic interventions had a small, positive effect on PA, even when compared against equivalent interventions targeting individuals. Given this, and the possibility that positive PA or SB changes in one dyadic member could induce positive changes in the other member, dyadic interventions is a viable intervention strategy. Nevertheless, uptake of such interventions (relative to those targeting individuals) should be compared, along with their acceptability, to further ascertain the feasibility of such approaches. Shared target-oriented goals produced larger effect sizes than non-shared target-oriented goals. This finding suggests it might be more effective to target one person and encourage their partner to support them to increase PA, ensuring they both hold the same PA goal for the main target. There was also some evidence

that dyads comprising peers/friends may be particularly effective but this effect could have been confounded with the effect of shared target-oriented goals. Dyadic interventions produced a small and homogeneous reduction in SB. In conclusion, utilising a dyadic based approach to behaviour change is a promising research area, thus, we hope that our findings provide useful directions for future intervention research.

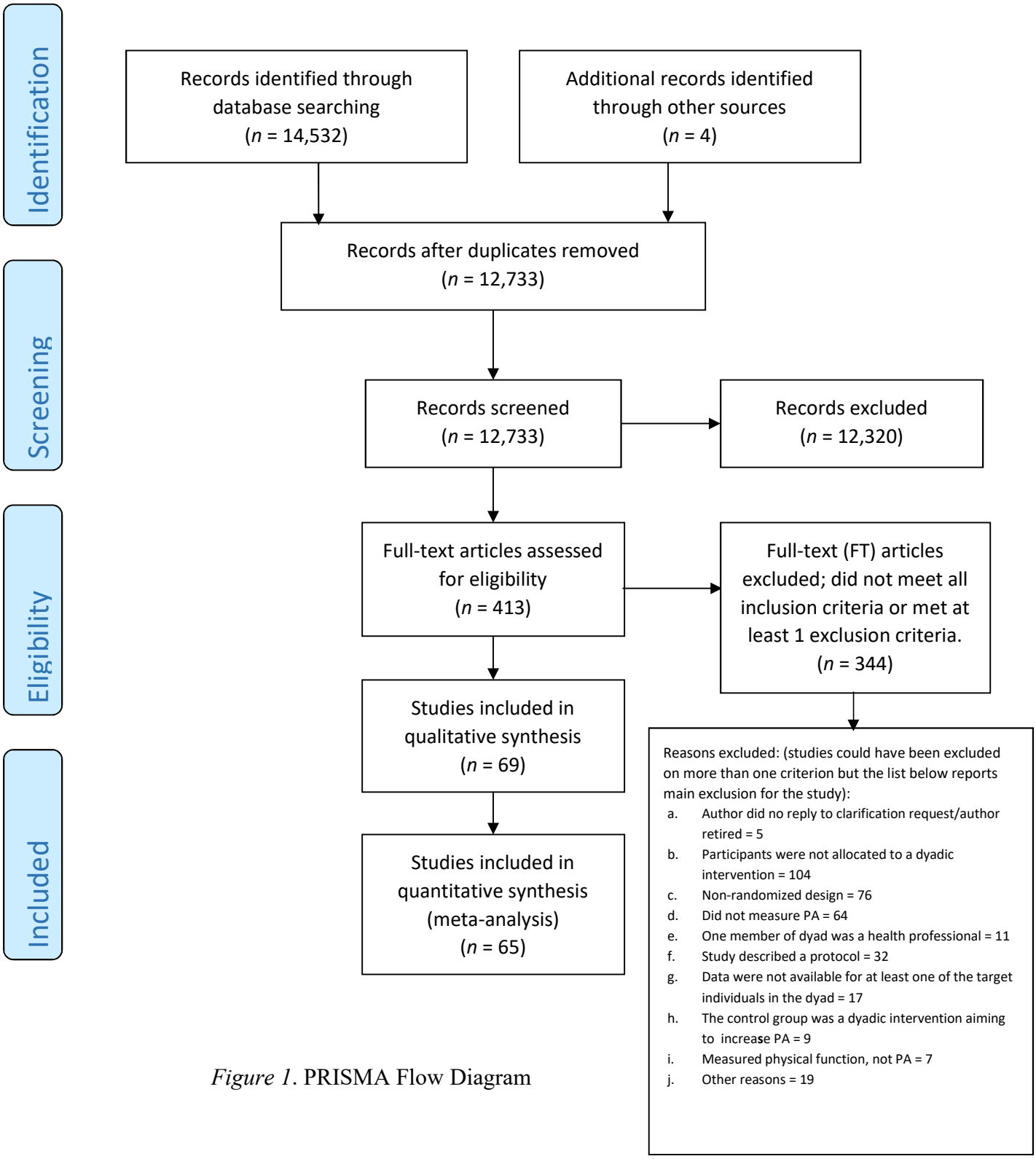

Figure 1. PRISMA Flow Diagram

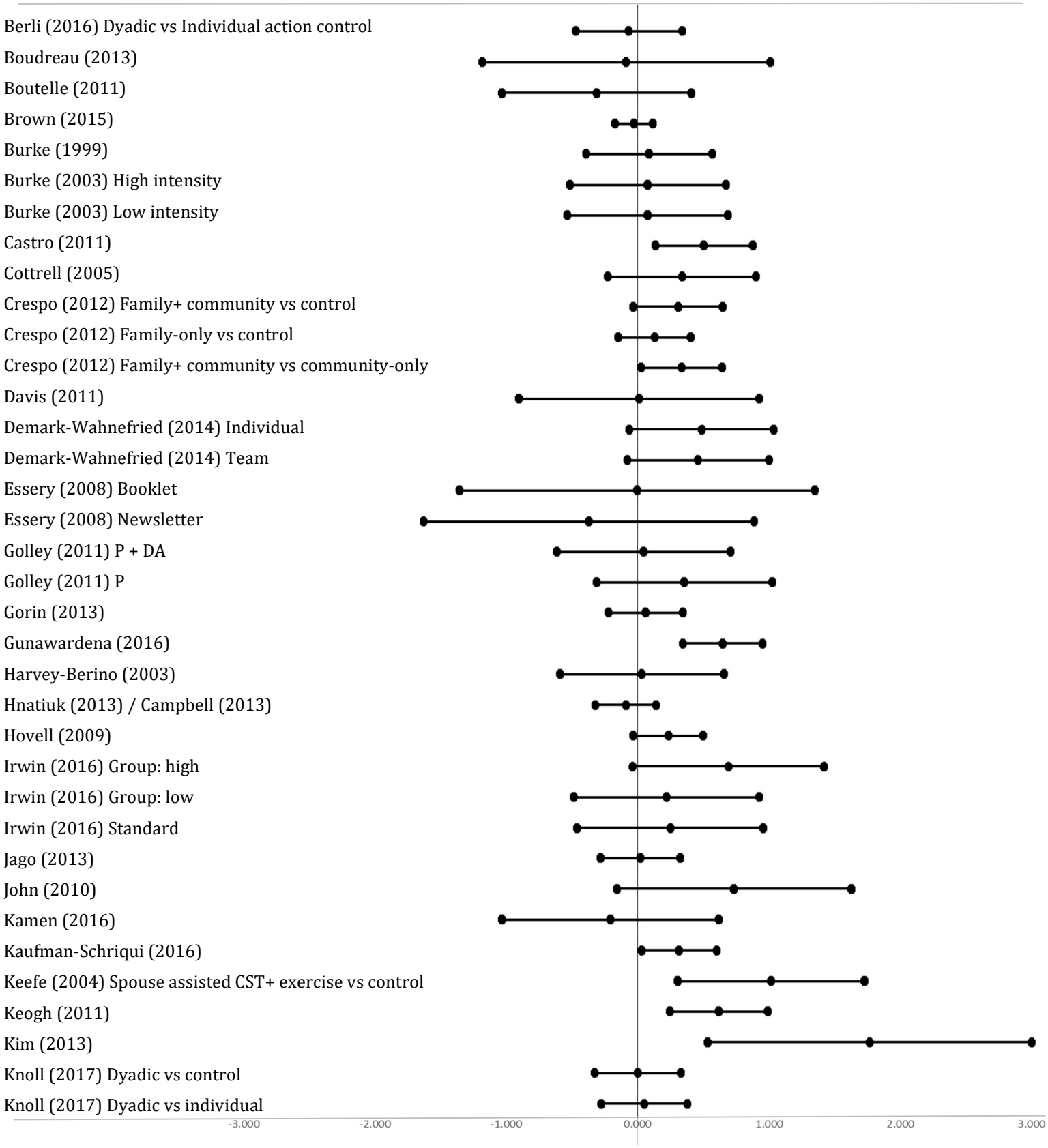

Figure 2. Effect size distribution of dyadic interventions for promoting PA.

II = implementation intentions, MI = motivational interviewing, HV = home visits. P = triple P, CST = pain coping skills training. *Note.* Some studies had more than one type of dyadic comparison condition

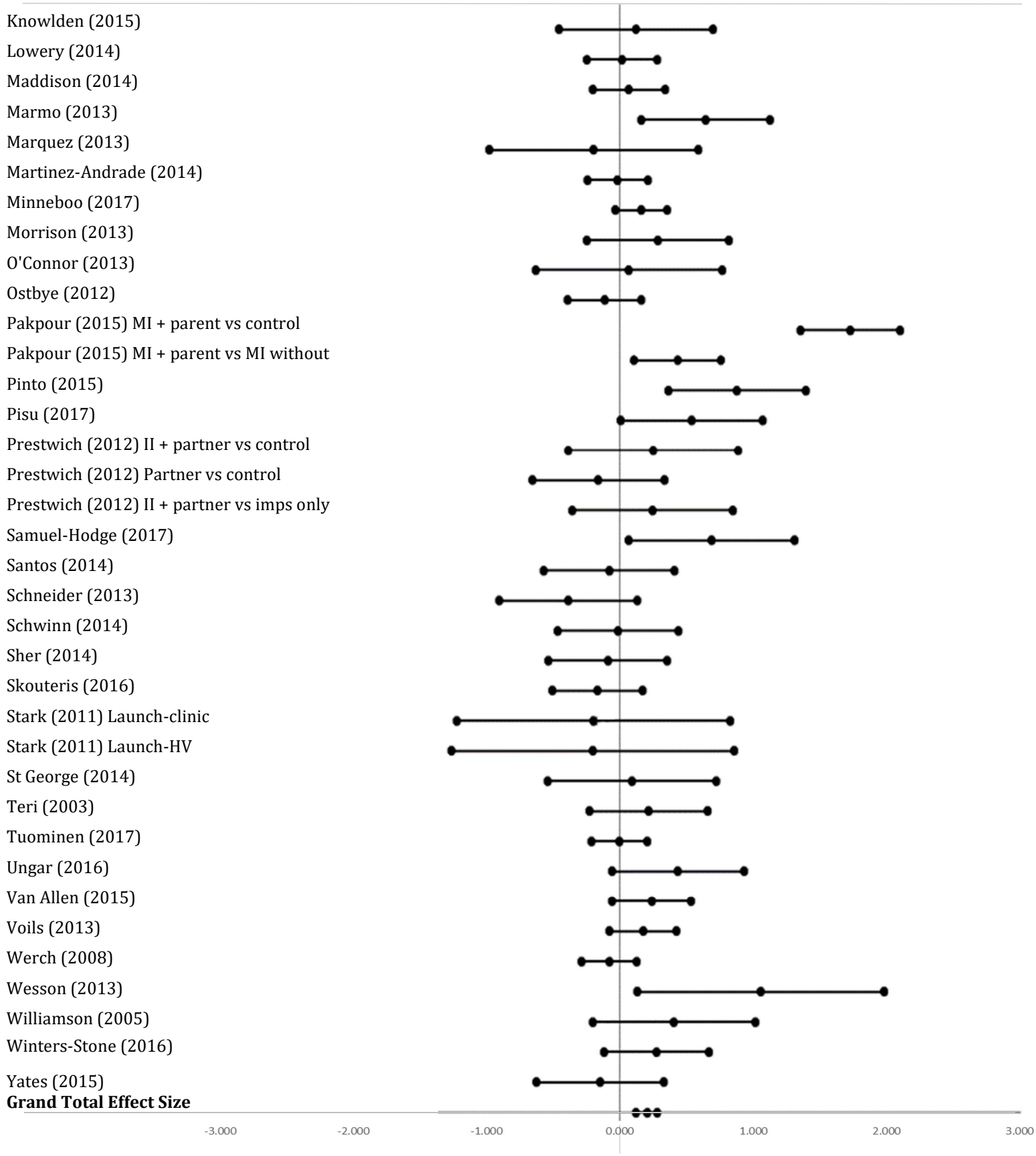

Figure 2. Continued…

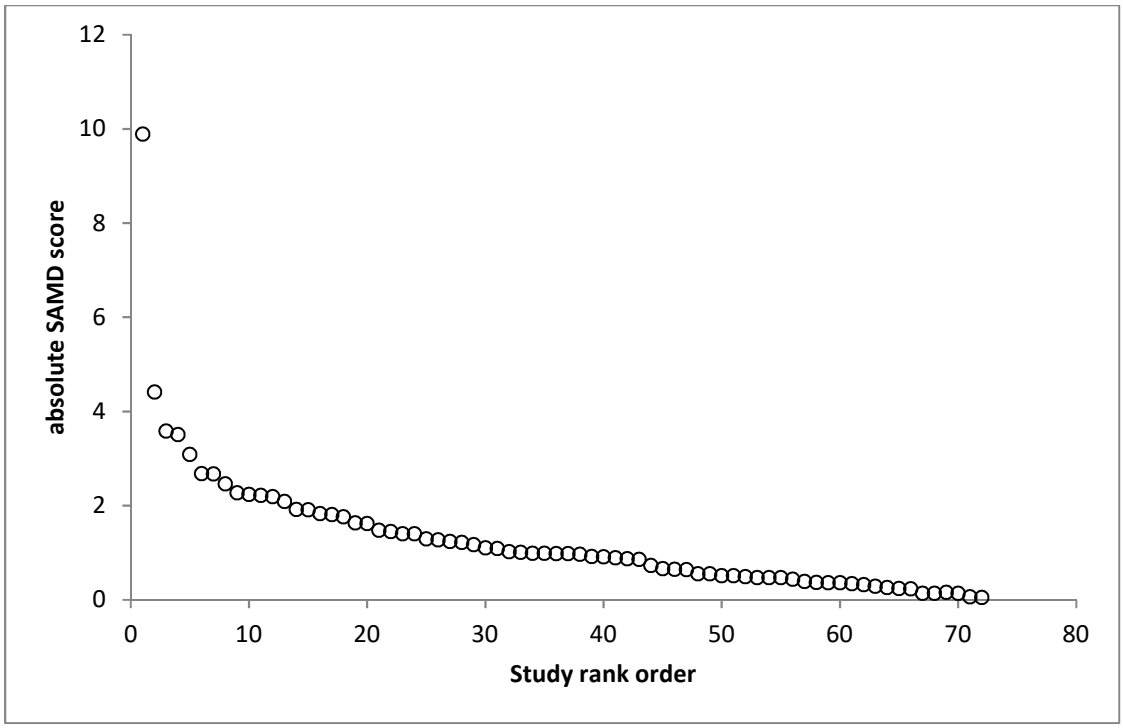

Figure 3. Scree plot indicating study outliers based on the SAMD statistic

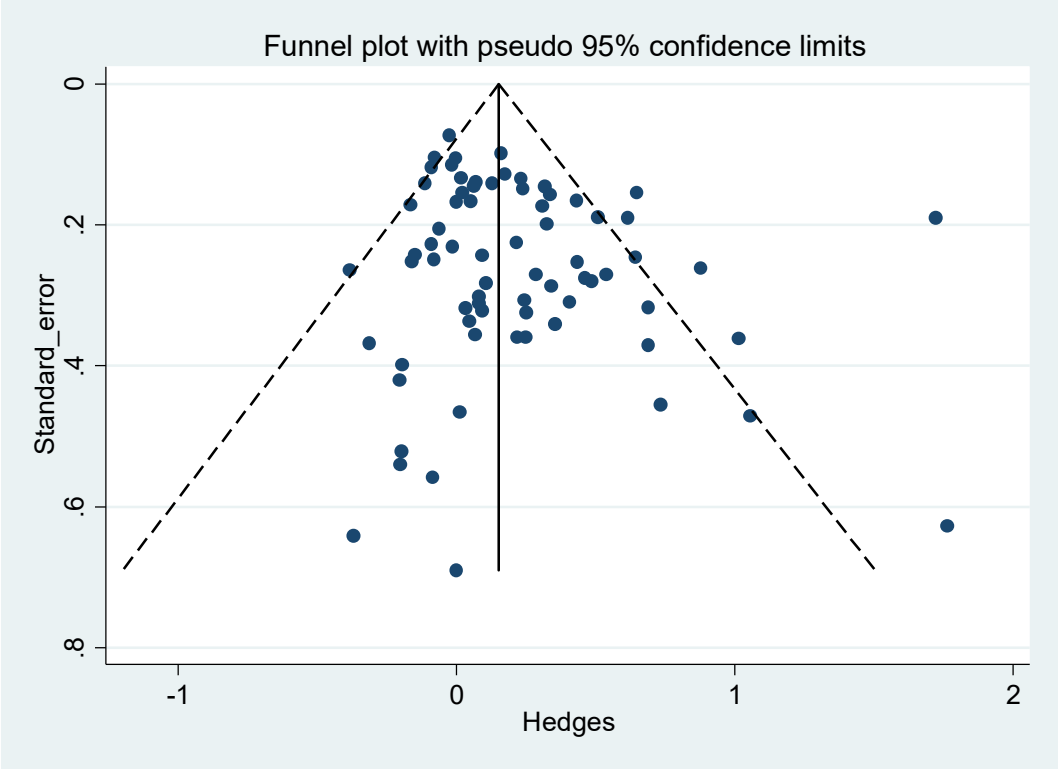

Figure 4. Funnel plot to determine publication bias in the included studies

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Supplementary Material

Table A1

Characteristics of Included Studies

First Author	Major Theory	Type of Dyad	Type of goals (Intervention)	PA Measure†	Type of PA	Type of Control	Duration of Delivery	Follow-up Length from Baseline/Start
Berli (2016)	Health action process approach	Couples	Partner-oriented	Objective	Any	Individual	10 texts over 14 days	28 days
Boudreau (2013)	Not stated	Caregiver-child (coded as parent-child)	Shared system "family goal setting"	Objective	Any	Waiting list	Approximately 12 contact days over 6 months	6 months
Boutelle (2011)	Behavioural reinforcement	Parent-child	Shared target	Self-reported	Any	Same BCTs except focused on Individuals not dyads- only parents involved in the intervention	Contact days not stated over 5 months	11 months
Boutelle (2013)[a]	Not stated	Parent-child	System-oriented	Self-reported (parent) Objective (child)	Any	Delayed treatment	12 days over 5 months	11 months
Brown (2015)	Self-determination theory	Family/ friends (56% spouses) Coded as participant + significant other	Shared system	Self-reported	Any	Other- dyadic, Not focused on PA/ skin cancer awareness	8 contact days over 1 year (2 newsletters, 5 phone calls, 1 face-to-face workshop)	1 year / 18 months
Burke (1999)	Not stated	Couples	Parallel self-oriented	Self-reported	Any	Delayed treatment	1 face-to-face, then 6 modules alternating mail with contact sessions over 16 weeks	16 weeks

Burke (2003)	Not stated	Couples	Parallel self-oriented	Self-reported	Any	Waiting list	6 modules over 16 weeks. Low intensity group- mailed the intervention High intensity group- alternating mail and face-to-face	1 year
Castro (2011)	Social cognitive theory and the transtheoretical model	Participant-peer	Shared target	Self-reported	Any	Other- diet. Not focused on PA (staff delivered telephone support for nutrition)	14 days (telephone), 1 day face-to-face and 12 monthly newsletters over 1 year	1 year
Cottrell (2005)	Not stated	Parent-child	System-oriented	Objective (pedometers), however parents inputted this data	Any	Individual- only children received pedometers, not parents	Contact days not stated over 4 weeks	4 weeks
Crespo (2012)	Health belief model, social cognitive theory, structural model of health behaviour	Parent-child	Partner-oriented	Self-reported	Any	Usual care/ Individual	7 face-to-face visits + 4 phone calls over 3 years	3 years
Davis (2011)	Not stated	Mother-child	System-oriented	Self-reported	Any	Usual care- single physician visit	4 days over 8 weeks	14 months
Demark-Wahnefried (2014)	Social cognitive theory, interdependence theory and communal coping	Mother-daughter	Team- Shared system Individual- Parallel self-oriented goals	Objective and self-reported	Any	Usual care- mailed booklets that were not focused on PA	6 days over 1 year	1 year

Essery (2008)	Not stated	Mother-child	Partner-oriented	Self-reported	Any	Delayed treatment	On 12 days received newsletters over 12 weeks Booklet condition- one booklet on first week of intervention	12 weeks
Feltz (2011)	Köhler effect	Participant-confederate	Coactive-parallel self-oriented Additive- shared system Conjunctive-shared target Coded in relation to the goal the participants perceived they had	Objective	Strength	Individual	1 day	1 day
Feltz (2012)	Köhler effect	Participant-confederate	Moderate-shared target Low- shared target High- shared target	Objective	Strength	Individual	1 day	1 day

Forlenza (2015) Our analysis focused on the virtually live partner vs. individual control as the other conditions distorted the confederate to make them less human in appearance	Köhler effect	Participant-confederate	Shared target	Objective	Strength	Individual	1 day	1 day
Golley (2011)	Child development theory and social learning principles	Parent-child	System-oriented- "parent aiming to increase child and family activity"	Self-reported	Any	Waiting list	P + DA- 15 days over 6 months P- 8 days over 8 weeks	1 year
Gorin (2013)	Social ecological models	Participant + household member (coded as participant + significant other)	Shared system	Self-reported	Any	Standard behavioural treatment-miscellaneous	52 days over 18 months	18 months
Gunawardena (2016)	Based on their own previous theory and experience	Mother-child	Shared target-child increasing mother's PA	Self-reported	Any	Usual care	Contact days not stated over 1 year	1 year
Gunnarsdottir (2011)[a]	Not stated	Parent-child	Shared target	Self-reported	Any	Standard care. Dyadic- not focused on PA. Nutrition counselling	22 contact sessions over 4 months/11 weeks	16 months

Harvey-Berino (2003)	Not stated	Mother-child	Partner-oriented-mother changing child's PA	Objective	Any	Other- dyadic, BCTs not focused on PA. Parenting skills training for the mother.	Contact days not stated over 16 weeks	16 weeks
Hnatiuk (2013) / Campbell (2013) Linked to Lioret (2012)	Social cognitive theory. Parenting support theory	Mother-child	System-oriented- mother modelling activity behaviours to increase child's PA	Objective (for the child but self-reported for the mother)	Any	Usual care/booklet not focused on obesity	6 days over 15 months	16 months
Holthoff (2015)[a]	Not stated	Caregiver-person with dementia	Shared target	Objective	Any	Usual care	36 days over 12 weeks	24 weeks
Hovell (2009)	Not stated	Parent-child	System-oriented	Self-reported	Any	Other- dyadic, child safety	8 days over 8 weeks	12 months
Irwin (2012)	Köhler effect	Participant-confederate	Coactive condition Parallel self-oriented Conjunctive condition-Shared target	Objective	Bike	Individual	6 days over 4 weeks	4 weeks
Irwin (2013)a	Köhler effect	Participant-confederate	Partner + encouragement condition-Shared target Partner without encouragement-Shared target	Objective	Strength	Individual	1 day	1 day

Irwin (2013)b Dissertation	Köhler effect and the transtheoretical model of behaviour change	Participant-confederate	Conjunctive condition- Shared target Coactive condition- Parallel self-oriented	Objective	Any	Individual	8 days over 8 weeks	8 weeks
Irwin (2016)	Carron and Spink's team-building model	Peer-peer	High- shared system Low- shared system Standard- shared system	Objective	Strength	Individual	1 day	1 day
Jago (2013)	Self-determination theory	Mother-child (1 father in the control condition)	System-oriented	Objective	Any	Delayed treatment	8 days over 8 weeks	16 weeks
John (2010)	Family centered care	Parent-child	System-oriented	Self-reported	Any	Delayed treatment	1 day	2 months
Kamen (2016)	Social support and social control theories	Caregiver-cancer survivor	Shared system	Objective	Any	Individual	6 days contacted to check adherence over 6 weeks	6 weeks
Kaufman-Shriqui (2016)	Ecological model	Mother-child	A mixture between system-oriented and parallel self-oriented	Self-reported	Any	Usual care	For children- 10 days of intervention contact over 15 weeks For parents- 13 contact days over 15 weeks	6 months
Keefe (2004)	Gate control theory	Spouses	Shared target	Objective	Strength	Usual care	12 group sessions + 36 exercise sessions over 12 weeks	12 weeks

Keogh (2011)	Self-regulatory model	Participant-family member (Coded as significant other)	Shared target	Self-reported	Any	Usual care	3 days over 3 weeks	6 months
Kim (2013)	Not stated	Caregiver - patient	Shared target	Self-reported	Any	Usual care	Not specified, 9 sessions were flexible manner as long as completed over 9 weeks	3 months
Knoll (2017)	Implementation intentions	Couples	Shared target	Objective	Any	Individual/ Other-dyadic task not focused on PA	1 day	7 weeks
Knowlden (2015) Linked to: Knowlden (2016) Follow-up one year efficacy	Social cognitive theory	Mother-child	System-oriented	Self-reported	Any	Dyadic- child focus. General health knowledge	4 days over 4 weeks	60 weeks
Lowery (2014)	Not stated	Person with dementia-carer	Mixture between system-oriented and parallel self-oriented	Self-reported	Walking	Usual care	Contact days not stated over 12 weeks	26 weeks
Maddison (2014)	Social cognitive theory and behavioural economics theory	Caregiver-child	System-oriented	Self-reported	Any	Delayed treatment	6 days over 20 weeks	24 weeks
Marmo (2013)	Social cognitive theory	Friend-friend	Partner-oriented	Self-reported	Any	Usual care	1 day	1 week

Marquez (2013)	Not stated	Participant-member of social network	Shared system	Self-reported	Any	Individual	12 days over 12 weeks	24 weeks
Martinez-Andrade (2014)	Chronic care model	Parent-child	Partner-oriented	Self-reported	Any	Usual care	6 days over 6 weeks	6 months
Minneboo (2017)	Not stated	Couples	Shared system and Shared target	Self-reported	Any	Usual care	1 year (depending on program)	1 year
Morrison (2013)	Not stated	Parent-child	System-oriented	Objective	Any	Usual care	Approximately 7 days over 10 weeks	11 weeks
O'Connor (2013)	Social cognitive theory and parenting theories	Parent-child	Mixture between system-oriented and parallel self-oriented	Objective	Any	Waiting list	Up to 12 contact days within 7 months completion	7 months
Ostbye (2012)	Social cognitive theory	Mother-child	System-oriented	Objective	Any	Dyadic- not focused on PA, reading	8 days (mailed), 8 days (telephone), 1 semi-structured group session over 10 months	22 months
Pakpour (2015)	Not stated	Mother-adolescent/ child	Shared target	Self-reported	Any	Usual care/ Individual	6 MI contact days over 1 year (extra session for parents in the MI + parent group)	1 year

Pinto (2015)	Transtheoretical model and social cognitive theory	Participant-volunteer/peer	Shared target	Objective and self-reported	Any	Other- dyadic, breast cancer	12 days over 12 weeks	24 weeks
Pisu (2017)	Cognitive interaction and intimacy model	Couples	Shared system	Self-reported	Any	Waiting list	12 sessions over 12 weeks	12 weeks
Prestwich (2012)	Theory of planned behaviour, protection motivation theory, implementation intentions.	Participant + significant other	Collaborative II condition- Shared system Partner without IIs condition- shared target	Self-reported	Any	Individual/ Usual care	1 day	6 months
Samuel-Hodge (2017)	Social interdependence and social support theories	Participant-family member (Coded as significant other)	Shared system	Self-reported	Mixed-Walking and general	Waiting list	20 sessions over 20 weeks	20 weeks
Santos (2014)	Not stated	Young child-Older child	Shared system; "participating in the go move activity together"	Objective	Any	Delayed treatment	Contact days unclear over 10 months	9/10 months
Schneider (2013)	Family systems theory and social cognitive theory	Caregiver-adolescent	Shared system	Objective	Any	Other- dyadic, broad range of health topics	8 days over 8 weeks	8 weeks
Schwinn (2014)	Not stated	Mother-daughter	Shared system	Self-reported	Any	Usual care	3 days over 3 weeks	5 months after receiving the program

Sher (2014)	Cognitive behavioural couples therapy and self-determination theory. Transtheoretical model	Couples	Shared target	Self-reported	Any	Individual	18 days over 24 weeks	18 months
Skouteris (2016)	Learning and social cognitive theory	Parent-child	Partner-oriented	Self-reported	Any	Waiting list	10 face-to-face days and parents received 10 handouts over 10 weeks	12 months post-intervention
Stark (2011)	Social cognitive theory	Parent-child	Mixture of system-oriented and parallel self-oriented goals	Objective	Any	Other- enhanced standard of care, paediatric counselling	18 days over 6 months	1 year
St. George (2014)	Social cognitive theory, self-determination theory, family systems theory	Parent-adolescent	Mixture between system-oriented and parallel self-oriented	Objective	Any	Other- dyadic, one of six general health topics	6 sessions over 6 weeks	6 weeks
Teri (2003)	Not stated	Patient-caregiver	Shared target	Self-reported (by caregiver)	Any	Usual care	12 days over 3 months	2 years
Tuominen (2017)	Not stated	Mother-child	Shared system	Objective	Any	Usual care	1 day (sent video) over 8 weeks	8 weeks
Tymms (2016)[a] PL group not dyadic, focused on the mentoring, combination and control	Self-efficacy and agency	Peer-peer	Shared target	Objective	Any	Waiting list	6 contact days over 6 weeks	6 weeks after the intervention

Ungar (2016)	Health action process approach	Peer-peer	Shared target	Self-reported	Any	Miscellaneous	4 days over 4 weeks	14 weeks
Van Allen (2015)	Behaviour change techniques	Parent-child	System-oriented	Self-reported	Any	Dyadic- weight focused	10 days over 10 weeks	1 year + 10 weeks
Voils (2013) Linked to King (2014)	Social cognitive theory	Couples	Shared target and shared system	Self-reported	Any	Usual care	9 days over 10 months	11 months
Werch (2008)	Prospect theory and stage theory	Parent-adolescent/ child	Partner-oriented	Self-reported	Any	Miscellaneous	3 days over 3 weeks	4 months
Wesson (2013)	Allen's cognitive disabilities model	Person with dementia + carer	Shared target	Self-reported	Any	Usual care	Approximately 14 days over 12 weeks	4 months
Williamson (2005)	Not stated	Mother-daughter	Shared system	Self-reported	Any	Other dyadic-general health education, nutrition	4 face-to-face days over 6 months	6 months
Winters-Stone (2016)	Not stated	Spouses	Shared system	Self-reported /Strength measures-objective	Mixed-Strength and general	Usual care	12 days over 6 months	6 months
Yates (2015)	Social cognitive theory and social support theory	Spouses	Shared system	Objective	Any	Usual care	18 - 36 sessions over 6 - 12 weeks	6 months

Note:

[a] Included in the systematic review but not in the meta-analysis
If explicitly mentioned that there were family goals or role modelling of the mother, then the studies were coded as having shared system-oriented or system-oriented goals
† PA measure - coded in relation to the measures included in the meta-analysis
Shared target = shared target-oriented goals. Shared system = shared system-oriented goals

Table A2

Search Terms

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
(fathers and their child).mp.	(fathers and their child).mp.	TS=(fathers and their child)
(mothers and their child).mp.	(mothers and their child).mp.	TS=(mothers and their child)
(parents and their child).mp.	(parents and their child).mp.	TS=(parents and their child)
(women and their boyfriend).mp.	(women and their boyfriend).mp.	TS=(women and their boyfriend)
(boyfriend and girlfriend).mp.	(boyfriend and girlfriend).mp.	TS=(boyfriend and girlfriend)
sibling$.mp.	sibling$.mp.	TS=sibling$
(husband and wives).mp.	(husband and wives).mp.	TS=(husband and wives)
dyad$.mp.	dyad$.mp.	TS=dyad*
couple$.mp.	couple$.mp.	TS=couple$
partner$.mp.	partner$.mp.	TS=partner$
colleague$.mp.	colleague$.mp.	TS=colleague$
friend$.mp.	friend$.mp.	TS=friend$
(women and their partner$).mp.	(women and their partner$).mp.	TS=(women and their partner$)
(women and their husband$).mp.	(women and their husband$).mp.	TS=(women and their husband$)
spouse$.mp.	spouse$.mp.	TS=spouse$
mother-child.mp.	mother-child.mp.	TS=mother-child
family.mp.	family.mp.	TS=family
families.mp.	families.mp.	TS=families
marriage.mp.	marriage.mp.	TS=marriage
sexual partner.mp.	sexual partner.mp.	TS=sexual partner

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
buddy.mp.	buddy.mp.	TS=buddy
cohabitee.mp.	cohabitee.mp.	TS=cohabitee
coworker.mp.	coworker.mp.	TS=coworker
caregiv*.mp.	caregiv*.mp.	TS=caregiv*
pair*.mp.	pair*.mp.	TS=pair*
father-child.mp.	father-child.mp.	TS=father-child
(children* adj10 father*).ab.	(children* adj10 father*).ab.	TS=(children* and mother*)
(children* adj10 mother*).ab.	(children* adj10 mother*).ab.	TS=(children* and father*)
exp DYADS/	Parent-Child Relations/	
exp exercise/ or exp physical activity/	exp exercise/ or exp physical activity/	TS=(bicycl* OR bike* OR biking OR swim* OR swimming OR aerobic* exercise* OR rollerblading OR rollerskating OR skating OR exertion* OR ”strength training“ OR ”resilience training“ OR ”weight lifting“ OR travel mode*)
running/	running/	TS=((cycle OR cycling) AND (school* OR work OR workplace OR commut* OR travel* OR equipment OR facilit* OR rack* OR store* OR storing OR park* OR friendly OR infrastructure))
walking/	walking/	TS=(sport* OR walk* OR running OR jogging OR pilates OR yoga)
physical fitness/	physical fitness/	TS=((decreas* OR reduc* OR discourag*) AND (sedentary OR deskbound OR ”physical* inactiv*“))

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
swimming/	swimming/	TS=((promot* OR uptak* OR encourag* OR increas* OR start* OR adher* OR sustain* OR maintain*) AND (exercis* OR exertion OR keep fit OR fitness class OR yoga OR aerobic*))
(fitness adj class*).ti,ab.	(fitness adj class*).ti,ab.	TS=((promot* OR uptak* OR encourag* OR increas* OR start* OR adher* OR sustain* OR maintain*) AND (circuit* OR aqua*))
gardening/	gardening/	TS=((promot* OR uptak* OR encourag* OR increas* OR start* OR adher* OR sustain* OR maintain*) AND physical activ*)
exp SPORTS/	exp SPORTS/	TS=((promot* OR uptak* OR encourag* OR increas* OR start* OR adher* OR sustain* OR maintain*) AND gym*)
exp YOGA/	exp YOGA/	TS=((leisure OR fitness) AND (centre* OR center* OR facilit*))
recreation/	recreation/	TS=(exercis* AND (fit* OR train* OR activ* OR endur*))
(fitness adj (regime* or program*)).ti,ab.	(fitness adj (regime* or program*)).ti,ab.	TS=(physical AND (fit* OR train* OR activ* OR endur*))
(led walk* or health walk*).ti,ab.	(led walk* or health walk*).ti,ab.	TS=(led walk* OR health walk*)
((moderate or vigorous*) adj activ*).ti,ab.	((moderate or vigorous*) adj activ*).ti,ab.	TS=((moderate OR vigorous*) AND activ*)
cardiorespiratory fitness.ti,ab.	cardiorespiratory fitness.ti,ab.	TS=(cardiorespiratory fitness OR aerobic capacity)
aerobic capacity.ti,ab.	aerobic capacity.ti,ab.	TS=(fitness AND (regime* OR program*))
(physical adj5 (fit* or train* or activ* or endur*)).ti,ab.	(physical adj5 (fit* or train* or activ* or endur*)).ti,ab.	TS=(exercise OR physical fitness OR sport* OR fitness class*)

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
(multimodal transportation or alternative transport* or alternative travel*).ti,ab.	(multimodal transportation or alternative transport* or alternative travel*).ti,ab.	TS=(multimodal transportation OR alternative transport* OR alternative travel* OR recreation* OR pedestrianis* OR pedestrianiz*)
("use" adj3 stair*).ti,ab.	("use" adj3 stair*).ti,ab.	TS=(use AND stair*)
BMI.mp.	BMI.mp.	TS=BMI
weigh*.mp.	weigh*.mp.	TS=Weigh*
(exercis* adj5 (fit* or train* or activ* or endur*)).ti,ab.	(exercis* adj5 (fit* or train* or activ* or endur*)).ti,ab.	
((leisure or fitness) adj5 (centre* or center* or facilit*)).ti,ab.	((leisure or fitness) adj5 (centre* or center* or facilit*)).ti,ab.	
((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 gym*).ti,ab.	((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 gym*).ti,ab.	
((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 physical activ*).ti,ab.	((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 physical activ*).ti,ab.	
((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 (circuit* or aqua*)).ti,ab.	((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 (circuit* or aqua*)).ti,ab.	
((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 (exercis* or exertion or keep fit or fitness class or yoga or aerobic*)).ti,ab.	((promot* or uptak* or encourag* or increas* or start* or adher* or sustain* or maintain*) adj5 (exercis* or exertion or keep fit or fitness class or yoga or aerobic*)).ti,ab.	

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
((decreas* or reduc* or discourag*) adj5 (sedentary or deskbound or "physical* inactiv*")).ti,ab.	((decreas* or reduc* or discourag*) adj5 (sedentary or deskbound or "physical* inactiv*")).ti,ab.	
sport*3.ti,ab.	sport*3.ti,ab.	
walk*3.ti,ab.	walk*3.ti,ab.	
running.ti,ab.	running.ti,ab.	
jogging.ti,ab.	jogging.ti,ab.	
pilates.ti,ab.	pilates.ti,ab.	
yoga.ti,ab.	yoga.ti,ab.	
((cycle or cycling) adj5 (school$ or work or workplace or commut$ or travel$ or equipment or facilit$ or rack$1 or store$1 or storing or park$ or friendly or infrastructure)).ti,ab.	((cycle or cycling) adj5 (school$ or work or workplace or commut$ or travel$ or equipment or facilit$ or rack$1 or store$1 or storing or park$ or friendly or infrastructure)).ti,ab.	
bicycl*.ti,ab.	bicycl*.ti,ab.	
(bike*1 or biking).ti,ab.	(bike*1 or biking).ti,ab.	
(swim*1 or swimming).ti,ab.	(swim*1 or swimming).ti,ab.	
(exercis*3 adj5 aerobic*).ti,ab.	(exercis*3 adj5 aerobic*).ti,ab.	
rollerblading.ti,ab.	rollerblading.ti,ab.	
rollerskating.ti,ab.	rollerskating.ti,ab.	
skating.ti,ab.	skating.ti,ab.	
exertion*1.ti,ab.	exertion*1.ti,ab.	

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
strength training.ti,ab.	strength training.ti,ab.	
resilience training.ti,ab.	resilience training.ti,ab.	
weight lifting.tw.	weight lifting.tw.	
travel mode*1.tw.	travel mode*1.tw.	
(active adj (travel*4 or transport* or commut$)).tw.	(active adj (travel*4 or transport* or commut$)).tw.	
recreation*1.ti,ab.	recreation*1.ti,ab.	
(pedestrianis* or pedestrianiz*).ti,ab.	(pedestrianis* or pedestrianiz*).ti,ab.	
(randomized or randomised or placebo or randomly or trial).ab.	randomized controlled trial.pt.	TS=(randomized controlled trial* OR randomised controlled trial* OR RCT OR controlled trial* OR interrupted time series OR controlled before)
Random allocation/ or clinical trial/ or single-blind method/ or double-blind method/ or control groups/	controlled clinical trial.pt.	
program evaluation/ or evaluation/	(randomized or randomised or placebo or randomly or trial).ab.	
quasi-experiment$.ti,ab.	random allocation/ or clinical trial/ or single-blind method/ or double-blind method/ or control groups/	
(pre test or pretest or (posttest or post test)).ti,ab.	evaluation studies/	
trial.ti.	program evaluation/	
(time adj series).ti,ab.	Comparative study.pt.	

Psycinfo	Medline	Web of Science - Social Sciences Citation Index only
((evaluat$ or intervention or interventional) adj8 (control or controlled or study or program$ or comparison or "before and after" or comparative)).ti,ab.	quasi-experiment$.ti,ab.	
((intervention or interventional) adj8 (effect* or evaluat* or outcome*)).ti,ab.	(pre test or pretest or (posttest or post test)).ti,ab.	
((process or program*) adj3 (effect* or evaluat*)).ti,ab.	trial.ti.	
(controlled before or "before and after stud$" or follow up assessment).ti,ab.	(time adj series).ti,ab.	
	((evaluat$ or intervention or interventional) adj8 (control or controlled or study or program$ or comparison or "before and after" or comparative)).ti,ab.	
	((intervention or interventional) adj8 (effect* or evaluat* or outcome*)).ti,ab.	
	((process or program*) adj3 (effect* or evaluat*)).ti,ab.	
	(controlled before or "before and after stud$" or follow up assessment).ti,ab.	
	Clinical Trial/	
No limit	English language and Full Text	English language and Article
Limit to 1996	Medline 1996-	Limit to 1996

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Berli 2016	+	+	?	–	+	–	+
Boudreau 2013	?	?	–	–	–	?	–
Boutelle 2011	+	?	?	?	+	+	–
Boutelle 2013	+	?	?	?	+	?	–
Brown 2015	+	–	–	–	+	+	+
Burke 1999	?	?	?	?	+	?	+
Burke 2003	+	?	?	?	+	+	–
Castro 2011	+	?	?	+	+	+	+
Cottrell 2005	?	?	?	?	?	?	–
Crespo 2012	?	?	?	+	+	+	–
Davis 2011	?	?	?	?	?	+	+
Demark Wahnefried 2014	+	?	?	–	+	+	–
Essery 2008	+	?	?	?	?	?	–
Feltz 2011	?	?	?	?	+	?	–
Feltz 2012	+	?	?	?	+	?	–
Forlenza 2015	?	?	?	?	+	?	–
Golley 2011	+	+	?	+	–	–	–
Gorin 2013	?	?	?	?	+	?	+
Gunawardena 2016	?	?	?	?	+	+	–
Gunnarsdottir 2011	?	?	?	?	+	?	–
Harvey Berino 2003	?	?	?	+	+	?	–
Hnatiuk 2013	+	+	–	+	–	–	–
Holthoff 2015	?	–	?	+	+	?	+
Hovell 2009	+	?	?	?	+	?	–
Irwin 2012	?	?	?	?	?	?	–
Irwin 2013a	+	+	?	–	+	?	–
Irwin 2013b (dissertation)	?	?	?	?	+	?	–
Irwin 2016	?	+	?	?	+	?	–
Jago 2013	+	?	?	?	+	+	–
John 2010	–	–	?	?	+	?	–
Kamen 2016	?	?	?	?	+	+	–
Kaufman Shriqui 2016	–	+	?	+	+	?	+
Keefe 2004	?	?	?	?	+	+	–
Keogh 2011	+	+	–	+	+	+	+
Kim 2013	+	?	–	–	+	?	–
Knoll 2017	+	?	?	?	+	?	+

Figure A1. Risk of Bias Summary for Each Study

Knowlden 2015	+	+	?	?	+	+	+
Lowery 2014	+	–	?	+	+	–	–
Maddison 2014	+	+	–	–	?	+	–
Marmo 2013	?	?	?	?	–	?	–
Marquez 2013	?	?	?	?	+	?	–
Martinez Andrade 2014	+	+	+	–	+	?	+
Minneboo 2017	+	–	–	–	+	+	–
Morrison 2013	+	+	?	+	+	–	–
O'Connor 2013	+	?	–	–	+	?	–
Ostbye 2012	+	?	?	?	?	?	+
Pakpour 2015	+	–	?	+	+	?	+
Pinto 2015	+	?	+	+	+	?	+
Pisu 2017	?	?	?	+	+	?	–
Prestwich 2012	+	+	?	–	+	?	+
Samuel Hodge 2017	+	?	?	+	?	?	–
Santos 2014	+	+	?	+	+	?	+
Schneider 2013	+	–	?	?	+	?	–
Schwinn 2014	?	?	?	?	+	?	–
Sher 2014	+	?	?	?	+	?	+
Skouteris 2016	+	–	?	?	+	?	+
Stark 2011	+	+	?	+	+	+	+
St George 2014	+	?	?	+	+	?	+
Teri 2003	?	?	?	+	+	+	+
Tuominen 2017	+	+	–	–	+	–	+
Tymms 2016	+	+	?	?	?	+	+
Ungar 2016	?	?	?	?	+	+	–
VanAllen 2015	+	?	?	?	+	?	+
Veils 2013	+	+	?	+	+	+	+
Werch 2008	?	?	?	?	+	?	–
Wesson 2013	+	+	?	+	+	?	–
Williamson 2005	?	?	–	–	+	?	–
Winters Stone 2016	+	+	?	+	+	–	+
Yates 2015	+	?	?	+	+	?	+

Table A3

Multivariate Meta-Regression Controlling for All Other Study Characteristics which were Associated with Effect Sizes

Moderator	*B*	Lower limit 95% CI	Upper limit 95% CI	*P*
Shared target-oriented goals	0.17	-0.02	0.35	.07
Objective PA only	-0.17	-0.34	-0.00	.04*
Control- usual care	0.01	-0.17	0.19	.94
Other country	0.16	-0.07	0.39	.16
ROB: Blind outcome assessor (high/unclear)	-0.16	-0.32	0.00	.06
Clinical	0.07	-0.13	0.27	.49

Note: PA= Physical Activity, ROB: risk of bias. Clinical= studies targeting clinical populations compared to studies targeting non-clinical populations

Table A4

Multivariate Meta-Regression for Significant Predictors that were confounded with Shared Target-Oriented goals

Moderator	*B*	Lower limit 95% CI	Upper limit 95% CI	*P*
Shared target-oriented goals	0.17	-0.02	0.37	.09
Other country	0.18	-0.04	0.41	.10
Clinical	0.15	-0.05	0.36	.13

Appendix B

Studies Included in the Review

Berli, C., Stadler, G., Inauen, J., & Scholz, U. (2016). Action control in dyads: A randomized controlled trial to promote physical activity in everyday life. *Social Science & Medicine, 163*, 89-97. doi:10.1016/j.socscimed.2016.07.003

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	34
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	35
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	36
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	39
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	39
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	39-40
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	40
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplementary materials 2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	39-40
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	40
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	40-41
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	41
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	41
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	42

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Supplementary materials 3 and page 48
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	41-42
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	55
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary materials 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Supplementary materials 3
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	56-57
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	43
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	43
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	46-47 & 48-49
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	49
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	52
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	53
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	34

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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*Additional analysis to check the impact of including an extra comparison from Keefe (Spouse-
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paper only reports data for 2 out of the 3 outcomes (for the 3rd DV, the ES was estimated,
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CHAPTER THREE:

"We are in This Together":

A Dyadic Physical Activity Intervention with Postpartum Mums and a Significant Other in Their Lives

Carr, R.M., Quested, E., Stenling, A., Thøgersen-Ntoumani, C., Prestwich, A., Gucciardi, D.F., McVeigh, J., & Ntoumanis, N.

Abstract

A recent review (Chapter 2) found that dyadic interventions can be somewhat effective in increasing physical activity levels. In this study we aimed to test whether the effects of such interventions can be enhanced by providing additional support in terms of planning and fostering self-determined motivation. Inactive postpartum mothers and a study partner of their choice were recruited in Western Australia and through random allocation received 1 of 3 dyadic conditions: a minimal treatment control (n = 34), collaborative planning (n = 38), or collaborative planning with need supportive communication training (n = 30). The intervention lasted for 4 weeks and follow-ups were taken at week 12. We aimed to explore whether the additional motivational communication training would increase physical activity over-and-above planning alone, and the control. A small positive effect on total physical activity at follow-up was found for postpartum mothers in the collaborative planning group and for partners in the motivation + planning group. Partners also benefited in terms of vigorous activity from taking part in the collaborative planning + need supportive communication group (i.e., they were more likely to have non-zero minutes of vigorous PA). At the follow-up, postpartum mothers in the collaborative planning + need supportive communication group scored lower on personal autonomous reasons; in the same group and at the same time point, partners scored lower on confidence in their partner's support. To our knowledge, this trial was the first dyadic physical activity intervention aimed at postpartum parent couples. Although we showed that it is possible to engage postpartum mothers (n = 51 actors; 2 partners) and to a large extent their spouses (n = 43), planning and motivation communication strategies had somewhat limited effects in increasing levels of physical activity in this population. Our results can inform future dyadic studies about the challenges and considerations that need to be made for recruiting couples with young children in physical activity trials.

Regular PA is associated with increased quality of life and health; in contrast, physical inactivity is associated with morbidity, premature mortality, and a substantial economic burden (Ding, 2016). One population group prone to inactivity is new parents; for example, a study of first-time mothers showed a significantly larger decrease in minutes of MVPA in this group, compared to women without children (Rhodes et al., 2014). Further, in the same study both mothers and fathers expecting their second child showed lower bouts of MVPA, compared to couples without children. In a survey study of 8,312 adults, women who had a child living at home were significantly less likely to meet PA guidelines, compared to women with no dependent children (Carson, Adamo, & Rhodes, 2018). In another study it was reported that 77% of women had no advice on PA during the postpartum period (Ferrari et al., 2010). Alas, parents with very young children have received limited attention in the PA literature. Of the available studies, many have relied on mothers only, using cross-sectional designs with exclusive reliance on self-reports (Bellows-Riecken & Rhodes, 2008).

According to Troiano, McClain, Brychta, and Chen (2014) self-report measures attempt to quantify PA in terms of time periods engaged in a specific behaviour and may be more appropriate for behaviours not typically 'picked-up' by wrist-worn accelerometers (e.g., bouts of cycling). Wrist-worn accelerometers collect data on bodily movement over short time periods. Objective measures assess actual PA while self-report measures assess perceived PA, as with self-report measures people report the duration, they were active without taking into account fragmented activity e.g., short breaks in bouts of walking (Chastin et al., 2009). As parents are often time-poor and may need to integrate activity in between childcare tasks, wrist-worn accelerometers seem more appropriate to consider these breaks in activity.

As well as being time-poor, mothers with young children may experience difficulties in attending sessions for improving their PA (Fjeldsoe, Miller, & Marshall, 2013). PA interventions are more likely to engage mums if they elicit social support from a significant other in mothers' lives and address the barrier of inconvenient locations. Such support could involve, for example, mothers and a significant other (e.g., spouse) supporting each other to increase their levels of PA in the home.

For example, in the MobileMums intervention study, Fjeldsoe et al. (2013) 88 postnatal women took part and nominated a support person to help them reach their PA goals. Text messages were sent to the target participants (i.e., mothers) and their partners to check whether the mums had reached their weekly goal and to increase social support. Findings

showed significant increases in frequency of PA and walking of the mothers. However, the trial retention rate of 69% at week 13 was lower than expected from other trials.

Fathers' role in supporting mothers' PA is often neglected in current PA intervention programs. In challenging situations, such as having a new family member, people (e.g., mothers) often turn to their romantic partners for support (Berli, Bolger, Shrout, Stadler, & Scholz, 2018). Any concomitant health behaviour change in mothers may have a ripple effect on their partner's health behaviour. Research has shown that health behaviours are concordant across couples (Arden-Close & McGrath, 2017); for example, people often romantically partner with others of a similar health status (vanDellen, Boyd, Ranby, MacKillop, & Lipkus, 2016). Further, data from the Longitudinal Study of Healthy Ageing indicated that if one partner adopts a new healthier behaviour, their spouse is more likely to follow suit (Jackson, Steptoe, & Wardle, 2015). Collectively, this evidence suggests that although mothers and fathers are more likely to be alike than different in terms of their PA levels, changes in mothers' PA could have spill-over effects on fathers' PA. However, what is not known from such correlational data is whether such changes are more likely to be maintained if both partners help each other to increase their levels of PA by co-participating in a PA intervention. This is worth investigating given the important role of partner support in new parents (Berli et al., 2018).

Mothers and fathers may be influenced to a different degree by their social environment in terms of their levels of PA, due to inherent sex differences. For instance, Oliveira et al. (2014) found that affective support from a family member or close friend was more important for women's leisure time PA than it was for men. Molloy, Dixon, Hamer, and Sniehotta's (2010) prospective observational study showed that lower levels of social support for PA were associated with lower levels of PA, for women but not for men. Hamilton, Cox, and White's (2012) survey study tasked 252 mothers and 206 fathers to complete questionnaires at two time points, one week apart. They found that the indirect path of subjective norms on intention was significantly stronger for mothers compared to fathers. Collectively, these studies suggest that mothers rely more on the social environment to increase PA.

Such findings might be because mothers may feel they have less control over their PA participation than fathers, as they experience different facilitators and barriers for PA (Hankonen, Absetz, Ghisletta, Renner, & Uutela, 2010; Phongsavan, McLean, & Bauman, 2007). The most prevailing reason as to why mothers find it difficult to prioritize their own PA, is because the needs of the family come first (Lewis & Ridge, 2005). Hence, having

family members providing support and approval for the mother's PA may help negate the barriers of control and priorities. Brown, Brown, Miller, and Hansen (2001) conducted a survey of 543 mothers of young children from different socioecomic backgrounds, exploring the factors that prevent them from being active. The findings indicated that access to social support from spouses, family, and friends, places some women in a better position than others to negotiate barriers to PA participation. Thus, in relation to intervention strategies for mothers, it may be beneficial to strengthen how important referents (e.g. partners) provide support for mothers' PA engagement (Hamilton et al., 2012).

One way to provide such support is by enabling co-participation in PA. For example, in a study of 119 romantic couples who completed 28-day diaries on the PA support they gave and received (Berli et al., 2018), it was found that on days with high rather than low received support, PA was 25 minutes higher. Further, in a subset of 88 couples from the same study who engaged PA jointly with a partner, such co-participation accounted for about half of the effects of support on target person's PA. Co-participation in PA is thus an important way in which participants can provide support to each other. However, what is not known from such findings is whether such co-participation leads to equal benefits in PA and concomitant health and psychosocial outcomes for both members of the dyad.

Use of Planning to Promote PA

Another important strategy for increasing engagement in PA is planning. Parents have reduced opportunities to be active due to caring for young children (Hamilton & White, 2010) and hence they need to plan how to incorporate PA into their schedules. Hamilton et al. (2012) found that action planning and coping planning were mediators in the intention-behaviour relation. Action planning refers to planning when, where, and how one will be active; coping planning involves planning to overcome obstacles (e.g., lack of childcare).

Planning to exercise may be an effective strategy to foster confidence in PA. Koring et al. (2012) tasked 290 participants to complete questionnaires at 3 times on planning for PA, PA behaviour, and self-efficacy. They found that if a person had high self-efficacy, planning for PA was more likely to result in increased PA. However, it is not known whether such findings generalize to young parents in terms of their self-efficacy to engage in PA, or their efficacy about how much support they can receive from their partners to exercise, or their efficacy that their partners can engage in PA themselves.

When people plan collaboratively with a significant other to exercise (shared system-oriented goal), they often achieve greater PA levels, compared to when planning individually (self-oriented goal) or not planning at all (Prestwich et al., 2012). The few findings on studies

utilizing dyadic plans show modest effects (Keller et al., 2017). In Knoll et al.'s (2017) intervention, for example, romantic couples made a shared target-oriented PA goal for either themselves or their partner for 6-weeks. The findings showed no direct effects of dyadic planning on the target person's PA; however, for partners their vigorous PA increased but the changes were not maintained at 6 weeks post-intervention. However, a couple's relationship quality could be an important determinant of the effectiveness of couples' planning. In Knoll et al.'s study, the results showed that for the target person's PA levels, the effects were moderated by relationship quality. When couples had lower relationship quality, their activity decreased for those who planned with a partner how they would engage in PA, when compared to those who planned their PA on their own.

Close, highly committed relationships are more likely to benefit from joint goal pursuit (Fitzsimons, Finkel, & vanDellen, 2015). If parents are committed to their relationship and communicate with their partner in motivationally supporting ways (e.g., using non-pressuring language) then they might benefit more from shared plans. However, many dyadic studies involve mothers and their children, but not romantic partners. Sorkin et al. (2014) for example, recruited 89 Mexican American diabetic women and their adult daughters. The women attended face-to-face sessions and discussed PA and diet plans, and health behaviour goals that they found challenging. The mother-daughter dyads were encouraged to check in with each other each week and engage in activities such as walking together (shared system-oriented goal). The intervention was more effective than usual care in promoting significant changes in weight and healthy diet; unfortunately, there were no assessments of PA reported. Perceptions of health-related social support and persuasion increased, while undermining behaviours/language from the social network decreased. Sorkin et al. suggested that the intervention might have led mothers and daughters to serve as role models, providing motivational support for each other as they experienced dietary changes. However, the measurement of the source of the supportive or undermining behaviour was unclear ("important people in your life"), hence it was not possible to examine the effects of actors' behaviours on partners' behaviours and vice versa. Nevertheless, the findings highlight the need to explore how supportive or undermining behaviours and communication language from the immediate family influence PA levels in dyadic interventions.

Use of Adaptive Communication to Promote Motivation for PA

It is important to foster good quality communication, if spouses or other family members plan to exercise together. According to SDT (Ryan & Deci, 2017), fostering positive communication (e.g. emphasizing feeling connected to each other through engaging

in PA) can potentially increase autonomous motivation and enjoyment of PA and decrease controlled motivation (Ntoumanis, Quested, Reeve, & Cheon, 2018). Autonomous motivation refers to behavioural engagement due to intrinsic interests or personal value of the behaviour. In contrast, controlled motivation refers to behavioural engagement due to internal (e.g., feelings of guilt) or external pressures (e.g., from a spouse or a clinician). According to Ryan and Deci (2017), individuals will be more autonomously motivated when their significant other communicates with them in ways that support three basic psychological needs: autonomy (having choice), competence (feeling effectant) and relatedness (feeling connected to each other). Such need supportive communication includes behaviours such as provision of choice, perspective taking, positive feedback, and unconditional regard (Lim & Wang, 2009). Ng et al.'s (2012) meta-analysis of SDT studies in the health domain highlights the role of need support for promoting need satisfaction and autonomous motivation.

Creating a need supportive environment may have desirable effects on one's efficacy about themselves and others engaging in PA, although this hypothesis has not been tested with new parents. For example, in a sample of Singaporean students (n = 990) the degree of which their teacher created a highly relatedness-supportive environment was related to greater proxy/other efficacy (belief in other students to do well) and relation-inferred self-efficacy (belief that other students have in on one's own ability to do well; Jackson, Whipp, Chua, Dimmock, & Hagger, 2013). Further, in this study, relational efficacy beliefs predicted autonomous motivation for engaging in physical education.

Autonomous motivation also predicts whether people will be successful in fulfilling their PA plans. For example, in the Koestner, Otis, Powers, Pelletier, and Gagnon (2008) study, 409 high school students reported how often they made plans for how, when, and where they would pursue their most important goal. Autonomous motivation was significantly and positively correlated with greater planning; in contrast, controlled motivation was unrelated to implementation planning. Planning was, in turn, highly related to goal progress. Most of the research, however, examining motivation and PA has done so from the perspective of personal-autonomous regulation. This literature focuses on personal autonomy (i.e., "how much I enjoy PA") rather than relational autonomy (i.e., "how PA is important to my relationship with others"; Gore, Bowman, Grosse, & Justice, 2016).

People may engage in PA because this would benefit their loved ones (relationally autonomous reasons), because of their own interest and values (personally autonomous reasons), or because they are demanded or expected to by someone else (relationally controlled reasons), or due to external pressures, rewards or punishments (personally controlled reasons). It is currently unknown how such diverse personal and controlled reasons for PA engagement might affect PA levels in dyadic interventions.

The Present Research

Given the supporting evidence for the use of dyadic interventions to promote PA, this chapter described the piloting of a dyadic intervention with a population prone to inactivity (i.e., postpartum mothers). In Chapter 2 the issue was raised as to whether both dyad members were equally motivated and engaged in the intervention. We stressed how it is also important to promote amongst both members of a dyad self-determined (autonomous) motivation for PA, by fostering the needs of autonomy, competence, and relatedness (Ryan & Deci, 2000). In that chapter we also suggested that future studies should explore whether certain behaviour change techniques e.g. goal-setting (behaviour) are effective when used amongst different dyad types who pursue different types of goals. This chapter reports on a dyadic intervention using self-determination theory and goal-setting (planning) as its theoretical underpinnings. To examine the role of planning and need supportive communication in helping mothers and a study partner of their choice to increase PA levels, we designed and tested the Postnatal Exercise Partner-based project (PEEPS).[1] This was a 12-week randomised controlled trial of a dyadic PA program, with participants assigned to one of three conditions: a minimal treatment control (i.e., dyads with no planning or communication training), collaborative planning, or collaborative planning with communication training.

Mothers with young children aimed to increase their PA via exercising with a study partner (e.g., the father of their child, a family member, a friend). It was expected that (H1) dyads assigned to a collaborative planning and a collaborative planning + need supportive communication condition would increase PA more so than a control group, and that the (H2) collaborative planning + need supportive communication condition would increase PA over-and-above collaborative planning alone.

[1] Prior to the main trial, twelve postpartum parents (six couples) participated in semi-structured interviews. The purpose of these interviews was to discuss the barriers to exercise and the feasibility of planning and communication training in promoting mothers and fathers' PA. The parents disclosed that mothers and fathers cannot always exercise together due to difficulties during childbirth, or differences in fitness within the couple. Based on these discussions, the postpartum mothers could self-select any significant other to take part with them, not just the father of their child.

It was also expected that the collaborative planning + need supportive communication condition would report increases in need supportive behaviours in partners (H3a), personal and relational autonomous motivation (H4a), and reductions in controlling behaviours (H3b) and personal and relational controlled motivation (H4b); we did not expect any changes in these variables in the other two conditions. Lastly, we hypothesized that confidence would be greater in the two intervention groups than in the control (H5).

Method

Participants

Mothers were eligible if they had a child between the ages of 3 months to 2 years. The criteria was originally 3 months to 1 year but the age range was widened to allow more participants to take part. To be more inclusive, we also changed the eligibility criteria to allow pregnant women to be involved. Mothers self-selected a study partner (e.g., their romantic partner) to participate in the study. Mothers will hereby be referred to as the "participant" and the study partners as the "partner". Both had to be over the age of 18 years, and somewhat active or not active (i.e., less than 24 units on the LSI index of an adapted version of Godin's, 2011, PA Questionnaire). Mothers who were pregnant or dyads who had health problems, as identified by the PA Readiness Questionnaire (PAR-Q; Canadian Society for Exercise Physiology, 2002), had to seek medical permission prior to participation in the study. We had up to 8 months available to recruit. Fifty one mothers (aged 34.57 + 4.31), and 51 study partners (aged 38.84 + 9.30) received the intervention, of whom most were spouses (n = 43); see Figure 1.

Measures

At screening, both dyad members reported their age, postcode, and the number of children they had living at home. Postpartum parents were asked if they had social support networks for childcare and if they breastfed, as such factors can influence PA levels (Evenson, Aytur, & Borodulin, 2009; Pereira et al., 2007).

Primary outcome. This was total PA, measured via GENEActiv accelerometers (Version 4.08a), set to record at 12:00md on the first day at 60hz for 8 days. The data were converted to 60 second epoch periods for analysis. For a participant's data to be included in the analysis, they needed a minimum of 10 hours of wear time on 4 days. Esliger et al.'s (2011) criteria determined classifications into sedentary, light, moderate, and vigorous PA. Total PA was our primary outcome of interest. MVPA and total PA were calculated by adding together the relevant PA categories.

Secondary outcomes. Specific PA categories (i.e. **light, moderate, vigorous, MVPA, and sedentary time**), as assessed by the GENEActiv accelerometers, were our secondary outcomes. The Reasons for Health Scale by Gore et al. (2016) was used to assess different **motivations for PA.** This scale makes a distinction between 4 types of motivation/ reasons as to why people engage in PA. Following the stem "when I exercise I do so because.." participants had to rate how much they agree with different statements, for example … "the other people make it enjoyable" (relationally autonomous reason), "of the fun and enjoyment it provides me" (personally autonomous reason), "it is only important to someone close to me" (relationally controlled reason), "I would feel guilty, ashamed, or anxious if I did not" (personally controlled reason).

Need support provided by the partner was measured using the Williams, Grow, Freedman, Ryan, and Deci (1996) scale; **controlling partner behaviours** were measured using an adapted version of the Bartholomew, Ntoumanis, and Thøgersen-Ntoumani (2010) scale. We also used an adapted version of the Shields and Brawley (2006) **self-efficacy for exercise** questionnaire. This scale assessed relation-inferred self-efficacy ("how confident your study partner is in your ability to develop effective solutions to cope with potential barriers that can interfere with your exercise?"). It also assessed two components of proxy efficacy, namely confidence in the partner to exercise ("how confident are you that your study partner can schedule exercise sessions into his/her weekly routine so that s/he gets at least 30 minutes of exercise a day, 5 times per week?") and confidence in the partner to provide support ("how confident are you that your study partner can support you to set realistic, weekly exercise goals (e.g., exercising 5 days/week?"). Internal reliability estimates for all scales are presented in Table 6. The personal controlled reasons for exercise measure is not presented in the Results due to low internal reliability.

Procedure

An un-blinded investigator was responsible for recruitment and data collection. Participants were recruited via flyers, Facebook posts, and face-to-face from family and parenting centres in Perth, Western Australia. Dyads were randomised by the lead author in equal proportions to one of the three groups using a computerised random number generator. The dyads were randomised when at least one member of the dyad completed the baseline survey; both had to complete the survey to receive one of three workshops (see Figure 1).

Control Condition

In this workshop, the control group received general information about PA, current recommendations, and discussed the opportunities and barriers to being physically active.

The dyads spent 5-10 minutes thinking about whether to exercise together or separately and setting a goal for the desired activity. For instance, "I will play tennis twice a week". They were encouraged to discuss with their partner their plan. The aim was to reach the Australian PA guidelines (Department of Health, 2019) (i.e., engaging in 150 minutes/week of moderate-intensity PA, 75 minutes/week of vigorous-intensity PA), but they did not receive any targeted strategies beyond this information. Six participants received the workshop face-to-face; the majority received the workshop online (*n* = 28).

Intervention Conditions

Collaborative planning condition. Participants received an expanded version of the control group's workshop. Six participants received the workshop face-to-face; the majority received the workshop online (*n* = 32). In accordance with previous *collaborative implementation intention* research (Prestwich et al., 2012), dyads made joint plans to work towards meeting the Australian PA guidelines on a worksheet (Department of Health, 2019). Dyads considered what they could do to help their partner exercise, in the format "if it is situation (X) then WE will do (Y)", whereby both dyad members had a goal for both themselves and their partner to increase PA (shared system-oriented goal). Alternatively, they created the goal "if it is situation (X) then I will do (Y) and my study partner will do (Z)", whereby both dyad members, take it in turns, to pursue the goal for one person in the dyad to increase PA (shared target-oriented goal) or they exercised simultaneously (parallel self-oriented goal). We refer to this condition as *collaborative planning* rather than *collaborative implementation intentions* as participants did not need to engage in PA together, it may be more beneficial to target one person at a time and encourage their partner to support them to increase PA (see, Chapter 2).

Collaborative planning + need supportive communication condition. Participants received an expanded version of the collaborative planning condition's workshop, and a general introduction on need supportive communication based on SDT (Ryan & Deci, 2000). Six participants received the workshop face-to-face; the majority received the workshop online (*n* = 24). The dyads received a list of need supportive (see examples below) and controlling strategies (e.g. "discouraging questions or alternative opinions from your partner" or "uttering your demands without explanations"). They were asked to write what they will say to each other, and what they would avoid saying to each other. They were presented fictitious scenarios of dyads encountering difficulties when exercising and discussed what each person could say to make their partner feel supported in terms of their needs for autonomy, competence and relatedness. Examples included (a) "Encourage a sense of choice

for your partner when planning physical activities" (autonomy support), (b) "Give positive, accurate and meaningful feedback" (competence support), (c) "Give empathetic responses, acknowledge difficulties and negative feelings" (relatedness support) (adapted from Hancox, Ntoumanis, Thøgersen-Ntoumani, & Quested, 2015).

After the workshop

After the workshop the dyads were invited to join a password-protected Facebook group, one for each condition, to share their experiences and discuss materials. The Facebook group for the control condition created a place for participants to share exercise tips or websites. The collaborative planning condition Facebook group were encouraged to share their success and failures in pursuing their plans, and the collaborative planning + need supportive communication Facebook group were encouraged to share their tips on need supportive communication. Dyads were also provided access to a website, customized for each group. An online website and Facebook groups were deemed appropriate for conveying the study information as participants were recruited through these mediums, and mothers are often time-poor. On that website, they could view the current PA guidelines (all groups), a planning flowchart (collaborative planning + need supportive communication + collaborative planning), and communication tips using appropriate scenarios (collaborative planning + need supportive communication). In weeks 2-4 weekly text messages were sent to the dyads in the two intervention conditions to elicit feedback on their use of the plans (collaborative planning; collaborative planning + need supportive communication) and their communication styles (collaborative planning + need supportive communication). In a similar study (Fjeldsoe et al., 2013) messages were sent to the target participants (i.e., mothers) and their partners to check whether the mothers had reached their weekly goal and to increase social support. Findings showed significant increases in frequency of PA and walking of the mothers. When participants choose to receive text message reminders of ones' implementation intention plans, this results in increased PA (Prestwich, Perugini, & Hurling, 2009). In week 4, dyads were invited by the researcher to discuss via phone or email the materials and to make new plans and, if in the collaborative planning + need supportive communication group, to also discuss about communication strategies.

Participants were classed as receiving the allocated intervention when they watched the workshop video online or attended in person. The dyads were asked to watch the video together (if possible). They were required to email the researcher with the date they watched the workshop video online. Participants were told their group number but were unaware whether they were in the control or one of the two intervention groups. All measures were

completed at baseline (week 0), post-intervention (week 4) and follow-up (week 12). We decided to measure PA at 0, 1, and 3 months to correspond with previous work (Prestwich et al., 2012). We were unable to have a 6-month follow-up as we only had 12 months to complete the study, due to this work being part of the lead authors Doctor of Philosophy program. Not all participants were recruited at the same time, so there were several workshops and assessment sessions over a period of 6 months. In week 1, dyads attended a face-to-face workshop at a local University or a family and parenting center in Western Australia. Dyads who were unable to attend were emailed a recording of the workshop (n = 74 individuals) or received the content by Skype (n = 10 individuals). The recording for the control group lasted 25 minutes, the collaborative planning condition 32 minutes, and the collaborative planning + need supportive communication condition 40 minutes.

Statistical Analysis

Mplus version 8.2 (Muthén & Muthén, 1998-2018) was used for all analyses. To examine the effects of the intervention, we used Bayesian actor-partner interdependence models (APIM; Kenny & Ledermann, 2010). The APIM takes into account the interdependency within dyads both within and across time points. Separate models were estimated for the effects at post-intervention (i.e., after 4 weeks) and follow-up (i.e., after 12 weeks); we controlled for baseline scores in all models (cf. Vickers & Altman, 2001). To assess within-group differences over time we compared baseline vs. post-intervention, baseline vs. follow-up, and post-intervention vs. follow-up, using Hedges' g_{av} as effect size estimate (Lakens, 2013). Effect size magnitudes of 0.20, 0.50, and 0.80 were used to indicate small, medium, and large effect sizes (Cohen, 1988). Means and standard deviations (presented in Tables 2 and 3) were based on estimated sample statistics using the full-information maximum likelihood estimator (Enders, 2010) that included the covariates (i.e., accelerometer wear-time, age, socioeconomic index, and number of children was included for both actors (mothers) and partners; social support and breastfeeding were included for actors only) in the estimation.

Two dummy coded variables representing the collaborative planning group and the need supportive communication-collaborative planning group, respectively, were included as predictors to assess the main effects of the intervention (i.e., the control group was used as comparison group). We also controlled for a number of covariates (described above). To account for the skewed data of vigorous PA (i.e., some participants had zero minutes) we estimated a two-part regression model (Baldwin, Fellingham, & Baldwin, 2016). The two-part regression model has a binary part describing the probability of a non-zero value in

vigorous PA, and a continuous part for the rest of the distribution (Muthén, Muthén, & Asparouhov, 2017; Olsen & Schafer, 2001). Parameter estimates were evaluated using the 95% credibility intervals. If the interval did not include zero, a parameter was considered as a credible and statistically significant estimate (Zyphur & Oswald, 2015). Missing data were handled by including all available information in the analyses, similar to full-information maximum likelihood estimation (Asparouhov & Muthén, 2010; Enders, 2010).

The Bayesian APIMs were estimated using four Markov chain Monte Carlo chains and 100,000 iterations. The first 50,000 iterations were discarded as burn-in and the remaining 50,000 iterations were used to estimate the posterior distribution of the parameters. Chain convergence was assessed using the potential scale reduction factor (PSFR; Brooks & Gelman, 1998), with a low (e.g., < 1.05) and stable PSFR being considered as evidence of chain convergence. Model fit was evaluated using the posterior predictive *p* (PPP) value and its accompanying 95% confidence interval. PPP values around 0.50 with a 95% CI centering on zero were considered as evidence of a well-fitting model, whereas a low PPP value and a 95% confidence interval with a positive lower limit were used as evidence of a poor fitting model (Asparouhov & Muthén, 2010). The deviance information criterion (DIC) was used to compare models with different prior specifications; a lower DIC value indicates better model fit (Zyphur & Oswald, 2015). A DIC difference of 1-2 indicate that both models deserve consideration, whereas a difference of 3-7 (or more) between two competing models is considered evidence that the model with lower DIC has considerably more support (Spiegelhalter, Best, Carlin, & Van Der Linde, 2002).

We attempted to find previous studies from which we could derive priors for the main outcome total PA, but we were unable to locate prior information (i.e., point estimates) that could be directly applied to our analyses. For example, Carr et al.'s (2019) meta-analysis found a small positive effect (i.e., $g = 0.20$) of dyad interventions on PA of any type, however, translating this effect size to minutes of total PA is challenging, and no straightforward guidelines are available for such translation. Prestwich et al. (2012) used a similar design as the one in our study but assessed PA using self-report measures, not accelerometers, which makes the metric of the PA variables in the two studies incompatible. However, Prestwich et al. reported effect size estimates for the comparisons between groups and found small to medium effects of the dyad intervention, with Cohen's *d*s ranging from approximately -0.15 to 0.60, depending on comparison group, PA measure, and measurement point.

Despite the lack of directly compatible sources to derive prior information, we hypothesized that the dyad intervention would have a positive effect on the participants' total level of PA, hence, we specified informative mean and variance priors on the regression coefficients of the intervention effects, based on effect size estimates in Carr et al. (2019) and Prestwich et al. (2012). Based on Carr et al. (2019), we specified a prior mean of 15 to reflect a small effect of the intervention, which represents a difference of 15 minutes of total PA per day between the intervention group and control group at post-intervention and follow-up. Two different variance priors were examined, representing higher (*SD* = 7.5) and lower (*SD* = 15) degree of certainty in the prior mean. Based on Prestwich et al. we specified a prior mean of 30 to reflect a medium effect of the intervention, which represents a difference of 30 minutes per day between the intervention and control groups. Two different variance priors were examined, representing higher (*SD* = 15) and lower (*SD* = 30) degree of certainty in the prior mean. For the remaining parameters and the rest of the analyses, we relied on the default noninformative prior specification in Mplus (see Muthén & Muthén, 1998-2018, p. 775, for a description of the default priors when Bayesian estimation is used).

To understand the impact of the informative priors on the results we compared estimates from models with noninformative priors and informative priors by computing a percent relative deviation [(parameter estimate with informative priors) – (parameter estimate with noninformative priors)/(parameter estimate with informative priors)]*100 (Depaoli & van de Schoot, 2017). If the size of the discrepancy is small (e.g., < 1%) or moderate (e.g., 1-10%) and the substantive conclusions remain the same, the subjectivity of the prior has no impact or a small to moderate impact on the results. If, however, the discrepancy is moderate (e.g., 1-10%) or large (e.g., > 10%), and the substantive results differ, the subjectivity of the prior has had a large impact on the results.

Power Analysis

A Monte Carlo simulation study (Muthén & Muthén, 2002) using Mplus version 8.2 showed that with a sample size of 51 dyads, studies that included informative priors (as described in the Statistical Analysis section) showed that only prior specifications representing higher degree of certainty on the variance parameters yielded around 80% power (range 78-83%) to detect a medium effect of the intervention on total PA. We had 25-26% power to detect a medium effect of the intervention on total PA when using noninformative priors. A medium effect size was defined as an unstandardized regression coefficient of 30.00, which corresponds to a difference of 30.00 minutes of total PA after the intervention between the intervention and control groups. This estimation is based on the expectation that

the participants would meet the PA guidelines by the Australian Department of Health (2019).

Results

Descriptive Statistics and Within-Group Differences Over Time

Characteristics of the sample at screening are presented in Table 1. Descriptive statistics for actors' and partners' total PA, sedentary time, and psychosocial outcomes at baseline, post-intervention, and follow-up are presented in Tables 2 and 3, respectively. For actors, most effect sizes were in the small to medium range, and few consistent within-group effects were observed. For partners, most of the effect sizes were small (i.e., below 0.20). Descriptive statistics and effect size estimates of the within-group differences over time for light, moderate, vigorous, and MVPA are presented in the supplemental material Tables S2-S3. All the analyses were pre-specified and based on the 51 mothers (actors) and 51 partners in their originally assigned groups.

Between-Group Differences at Post-intervention and Follow-up

The APIM is graphically depicted in Figure 2. All effects within and between dyad members were freely estimated. We tested separate models for each outcome variable and for the effects at post-intervention and follow-up.

Primary outcome: Total PA. The results from the APIMs evaluating the intervention effects at post-intervention on total PA are presented in Table 4. Based on the DIC, Model E received less support than Models B and C (i.e., DIC difference of 3). The DIC difference was 2 or less between Models B, C, and D, hence, all of these models deserve consideration. Whereas Models B (prior mean = 15, *SD* = 15), and D (prior mean = 30, prior, *SD* = 30) indicated that the intervention effects were not credible (i.e., the 95% CIs included zero), the results from Model C (prior mean = 15, prior, *SD* = 7.5) indicated a credible effect for actors in the collaborative planning group (*B* = 15.54, 95% CI [1.55, 29.54]) and partners in the collaborative planning + need supportive communication group (*B* = 15.37, 95% CI [0.98, 29.65]). It is also noticeable that the percent relative deviation was large for all estimated intervention effects (i.e., > 100%), indicating a large impact of the prior specification in the results. Taken together, based on Model C with informative priors, we can infer that the intervention had a small positive effect on actors in the collaborative planning group and partners in the collaborative planning + need supportive communication group at post-intervention.

Similar results were observed at follow-up (see Table 5). Model J (prior mean = 30, *SD* = 15) received considerably less support then Model G (prior mean = 15, *SD* = 15),

indicated by a DIC difference of 3. The DIC difference between Models G, H, and I was 2 or less, indicating that they all deserve consideration. Whereas Models G (prior mean = 15, *SD* = 15) and I (prior mean = 30, *SD* = 30) indicated that the intervention effects were not credible, the results from Model H (prior mean = 15, prior *SD* = 7.5) indicated a credible effect for actors in the collaborative planning group (*B* = 17.15, 95% CI [2.86, 31.40]) and partners in the collaborative planning + need supportive communication group (*B* = 16.39, 95% CI [2.12, 30.62]). The percent relative deviation for actors in the collaborative planning group in Model H was 65.78%, whereas the percent relative deviation for the effect on partners in the collaborative planning + need supportive communication group was 34.36%. The percent relative deviation for the remaining effects with priors in Model H was large (i.e., > 100%). The discrepancy between the parameter estimates with noninformative priors and informative priors indicate that the prior specification had a large impact on the results. Taken together, based on Model H with informative priors, the intervention had a small positive effect on actors in the planning group and partners in the collaborative planning + need supportive communication group at follow-up.

To summarize, based on models with informative priors on the means and SDs of the intervention effects we tentatively conclude that the intervention had a small positive effect on actors in the collaborative planning group and partners in the collaborative planning + need supportive communication group at post-intervention and follow-up. However, due to the large impact of the prior specification on the results and similar model fit observed for models not indicating a credible effect, these findings need to be interpreted with caution.

Secondary outcomes: PA categories and self-reports. The intervention effects on the secondary outcome variables are presented in Tables S4-S16 in the supplemental material. Partners in the collaborative planning + need supportive communication group were 3.68 (95% CI [1.45, 6.82]) times more likely to have non-zero minutes of vigorous PA at follow-up, compared to the control group (Table S7). Actors in the collaborative planning + need supportive communication group scored lower on personal autonomous reasons (*B* = -0.51, 95% CI [-0.86, -.015]), and partners in the collaborative planning + need supportive communication group scored lower on confidence in their partner's support (*B* = -0.82, 95% CI [-1.37, -0.27]) at follow-up, compared to the corresponding values in the control group (see Tables S9 and S14). No other credible intervention effects were observed on the secondary outcome variables.

It is also noticeable that the partners' sedentary time had credible and positive effects on the actors' sedentary time at post-intervention (*B* = 0.35, 95% CI [0.10, 0.60]) and follow-

up (*B* = 0.27, 95% CI [0.38, 1.06]; see Table S4). Partners' levels of moderate PA also had credible and positive effects on actors' levels of moderate PA at post-intervention (*B* = 0.24, 95% CI [0.04, 0.43]) and follow-up (*B* = 0.43, 95% CI [0.21, 0.64]; see Table S6). Hence, partners' sedentary time and moderate PA appear to be associated with actors' sedentary time and moderate PA over time. We also noted that actors' personal autonomous reasons at baseline had a credible and positive effect on partners personal autonomous reasons at follow-up (*B* = 0.31, 95% CI [0.05, 0.56]). Hence, actors' personal autonomous reasons seem to have a long-term association with partners' personal autonomous reasons (see Table S9).

Discussion

In this 3-group RCT we examined the role planning and need supportive communication might play in helping mothers and a study partner of their choice to increase PA levels and improve their motivation and confidence for PA. We compared changes at post-intervention and follow-up across groups. The results showed a positive effect of the intervention on changes in total PA for actors in the collaborative planning group, and for partners in the collaborative planning + need supportive communication group at post-intervention and follow-up, compared to the control condition. These effects were small, but in line with the meta-analysis by Carr et al. (2019) on dyadic interventions to promote PA. We found partial support for Hypothesis 1 (H1), as the differences in PA between the control group and the two experimental groups were not equivalent for actors and partners. Contrary to H2 (which predicted that the collaborative planning + need supportive communication condition would have greater PA compared to the collaborative planning only condition), actors (mothers) had greater total PA in the collaborative planning comparison at the follow-up. This effect was mainly driven by increases in light activity. It could be that light activity is more manageable in this population, as first-time mothers attend to the daily workload of infant care and thus shift from sedentary behaviour to light activity (Rhodes et al., 2014). During our feasibility interviews in the pilot phase, mothers alluded to difficult births and how child-birth complications hindered their intentions to undertake MVPA, thus suggesting that light PA is easier to participate in. Further, there are many time-consuming responsibilities that are linked to infant care, such as household chores and returning to work (Connolly, Feltz, & Pivarnik, 2014), with many of these responsibilities involving light PA. Need supportive communication training may be less important for light PA as it can be accumulated through partaking in chores and childcare tasks. Further perhaps in the need supportive communication + collaborative planning condition, partners wanted to be more

autonomy supportive, so they provided less structure which undermined the PA pursuits of mothers, who need more structured PA.

We found no credible effects for partners (84% of whom were spouses) in our study in the collaborative planning condition in terms of total PA, but partners in the collaborative planning + need supportive communication condition showed improvements in vigorous PA compared to the control condition. Given that planning was available in both conditions, partners might have benefitted more from the motivational support available in the collaborative planning + need supportive communication condition. Such support might be less important for light PA which is easier to carry out and more incidental (Merom et al., 2014). Nevertheless, this explanation is tentative, given that there were no differences across conditions in perceptions of need supportive behaviours.

However, it is important to note that the priors did have a large impact on the results related to total PA (i.e., as indicated by the percent relative deviation). For some intervention effects (mostly at the post-intervention) there were relatively large differences in the magnitude, sign, and interpretation of the effects between models with informative and noninformative priors (Van de Schoot & Depaoli, 2014), which needs to be taken into consideration when interpreting the findings. The differences between models with informative and noninformative priors at post-intervention potentially reflect that parents need more time to implement their plans and motivation strategies than the time frame of our study.

Further, no corrections were made for multiple testing (cf. Althouse, 2016; Primo de Carvalho Alves & Sica da Rocha, 2019). The issue of correcting for multiple tests has sparked a lot of debate, particularly in relation to frequentist statistics and p-values (see e.g., Rothman, 1990 and Noble, 2009 for opposing views on this topic), and there is still no consensus regarding if researchers should adjust for multiple tests, and if so, how they should adjust. For Bayesian statistics there are also discussions if, and if so how, researchers should adjust for multiple tests (see e.g., Berry & Hochberg, 1999). When using Bayesian statistics, one way that automatically accounts for the fact that multiple hypotheses are being evaluated is the inclusion of prior model probabilities that depend upon the data in an appropriate way (Scott & Berger, 2010). There have also been other suggestions regarding how to deal with multiple testing when using Bayesian statistics (e.g., by using hierarchical models as proposed by Gelman, Hill, & Yajima, 2012), however, the accessibility of these methods to applied researchers is low (see e.g., de Jong, 2019). Regardless of the statistical framework used, one difficult issue with adjustments for multiple testing is to choose the number of tests

to include when making the adjustments, or to put it in other words, what constitutes a "family of tests"? This is often a spurious decision and no clear guidelines are available for this kind of decision. In the current study we did not adjust for multiple tests. Following suggestions by Althouse (2016), we assume that by describing what was done in the study and by reporting appropriate statistics, the readers can use their own judgment about the relative weight of the conclusions (see also Primo de Carvalho Alves & Sica da Rocha, 2019).

Motivation and confidence

We found no support for Hypotheses 3-5. Contrary to H3a, H3b, and H4b, there were no group differences in need supportive behaviours, controlling behaviours, or controlled motivation. Previous research has shown that need supportive training of 1-3 hours in duration, produces greater effect sizes than longer or shorter durations of the same training (Su & Reeve, 2011). As our collaborative planning + need supportive communication video was 40 minutes in duration, this might have been too short to produce increases in need support. Our training was relatively brief because mothers had limited time for the intervention and asking them to engage in a 3-hour workshop would not be feasible. Because the intervention did not increase need supportive behaviours, the reasons for PA did not become less controlled.

The findings for H4a and H5 were surprising. At the follow-up, compared to the control condition, actors (mothers) in the collaborative planning + need supportive communication group scored lower on personal autonomous reasons (counteracting hypothesis H4a), and partners scored lower on confidence in the mothers' ability to support them (counteracting hypothesis H5).

It is likely that in the collaborative planning + need supportive communication condition actors, through increased knowledge about motivation, were more able to accurately assess their degree of autonomous motivation, compared to the other groups which received no motivation training. Our study found planning to exercise together was not practical for many parent dyads. This may have led to decreased autonomous motivation and less confidence in partner support. Mothers, being time poor, did not sufficiently engage with the intervention, and, thus, were able to realize that their autonomous motivation for PA was low; their partners were also able to discern this lack of engagement by having less confidence in the mothers to support them.

Actor-Partner Effects

One possible reason for the lack of intervention effects may be that increasing the mothers' PA or motivation, may not result in similar changes for their partner. A 15-month intervention involved first-time parent groups, with sessions focusing on providing PA opportunities and parent modelling of eating and PA (Walsh et al., 2014). Mothers were asked to share and discuss lifestyle-related intervention resources with fathers and other carers. Despite beneficial effects of the intervention on mothers' obesity-related behaviours; no significant beneficial effects were observed on fathers' tv viewing, diet, or PA.

We however found some concordance among dyads, although we did not have any specific hypotheses for these relations. Over time, partners' sedentary time and moderate PA were associated with actors' corresponding values. Also, personal autonomous reasons for PA for actors at baseline were positively associated with personal autonomous reasons for partners at the follow-up. These findings are not surprising, given the literature on romantic partners has shown that health behaviours are concordant across couples (Arden-Close & McGrath, 2017) and, people often partner with others of a similar health status (vanDellen et al., 2016). There is also evidence of similar associations in best friend dyads' PA (Lopes, Gabbard, & Rodrigues, 2013), and parent-adolescent dyads in terms of autonomous motivation (Dwyer et al., 2017).

Strengths, Limitations, and Future Research Directions

We have shown that it is possible to recruit postpartum mothers and, to a large extent, their spouse to a dyadic PA intervention. This study provided an opportunity for postpartum mothers to take part in a PA intervention, without leaving their home, overcoming the barriers of inconvenient locations and high costs associated with postnatal PA classes (Saligheh, McNamara, & Rooney, 2016). We were inclusive in our approach and allowed mothers to self-select any significant other, increasing generalisability. We also provided more choice than Prestwich et al. (2012), as participants could exercise together or separately. Strengths of our study also include the use of a RCT design and the testing of two treatments groups against a minimal treatment group, the use of both face-to-face and online components, and the objective assessment of both actor and partner PA and sedentary behaviour levels. We fill an important gap in the literature, in that this is a dyadic intervention to promote PA that uses SDT as one of its theoretical frameworks and compares the use of planning with and without motivation training.

As with all field interventions, this study had limitations. Engagement with the Facebook website was poor; in fact, no participants posted on the collaborative planning condition's page. This may be due to the small number of participants who were in the

groups at any given time, as the workshop sessions were staggered over 6 months. The groups were designed to promote social connectedness, but participants waited for the researcher to initiate discussions, possibly because they did not know other participants. In hindsight, we should have initiated discussions among participants with researcher-led tips or invited their Facebook friends to join (as in Kernot, Olds, Lewis, & Maher, 2014).

There were several challenges with recruitment which impacted the way the intervention was delivered. If the participants attended a face-to-face session to meet others, they may have been more likely to engage in online discussion. We intended to run face-to-face workshops with groups of 3-4 pairs. The workshops were designed to prompt discussion among the dyads about how they can overcome barriers and to offer suggestions to the wider group. Most participants (n = 84) opted to watch a video of the workshop at home (for 10 individuals the researcher was also present), which is indicative of the challenges of offering a face-to-face intervention with this time poor population group. Thus, they missed out on connecting with a wider group. Miller, Trost, and Brown (2002) found that mothers who received printed information and participated in discussion groups with other young mothers were more likely to achieve PA recommendations.

We encouraged the dyads to create plans to exercise together or separately (while their partner provided support). This task proved challenging for dyads where the partner worked full-time or lived separately. Prestwich et al. (2012) found that when dyads plan to exercise together, they have greater PA compared to planning individually or not planning. We encouraged some pairs to phone each other to "check-in" when exercising separately (e.g. to ask their partner if they managed to carry out their plans or to offer need support). Future studies should explore further strategies to help parent dyads support each other when exercising individually, as collaborative plans were not suited for many dyads which comprised of postpartum mothers.

TGD theory discusses how more time together encourages communication about goals (Fitzsimons et al., 2015) and how this makes it possible for dyads to develop joint goals and divide and share pursuit of the goals. Dyads who have good communication skills may be more likely to coordinate their goals. Thus, as our intervention fostered communication between the dyads regarding their feelings and perspectives about their PA pursuit and goals, this may have helped them coordinate and share their goals. Due to our limited beneficial findings however, more work is needed on how to foster communication between the dyad, especially, if the dyad are pursuing PA separately.

TGD theory makes it clear that goals do not exist solely on the level of the individual and highlights the importance of dyad-level goals. Participants set goals in the format "if it is situation X then we will do Y" (a shared system-oriented goal) or the format "if it is situation X then I will do Y and my study partner will do Z". The latter goal is a shared target-oriented goal, if the *"my study partner will do Z"* part of the goal involves one dyad member supporting their partner to engage in PA by helping with childcare/house related tasks. The goal is a parallel self-oriented goal, when dyads use the "*my study partner will do Z*" part of the goal to pursue different physical activities. Both dyad partners however, were aiming to increase PA in the study, so when the dyads formed a shared target-oriented goal, they essentially alternated in taking on the supportive role so their partner can increase PA. Turn-taking may not be reflected in TGD theory. It could be inferred that at the 'study level' the dyad have a shared system-oriented goal (both want both to increase PA) but they may pursue this goal by making, for instance, shared target-oriented plans (planning for one person in the dyad to increase PA on X day/time).

According to TGD, motivation for interdependence is also important (Fitzsimons et al., 2015). Our collaborative planning + need supportive workshop attempted to promote intrinsic motivation for PA, by emphasizing the needs of autonomy, competence, and relatedness. Some dyads choose to exercise together and some separately, but in both situations, we encouraged the dyads to provide their partner support. Perhaps some relationship types (e.g., friends, parents, or siblings) are better suited to support their partner in different situations. For instance, a sibling who has had children may be a better source of emotional-support than one's spouse regarding pregnancy-related issues (Finkel, Hui, Carswell, & Larson, 2014); and the same sibling may have better advice regarding exercising post child-birth.

An adults most important social relationship is with their spouse (Finkel et al., 2014). Couples thus may experience greater interdependence (i.e., more dependence on each other) than other types of dyadic relationships (e.g., siblings, parents). The content of our workshops may have needed to be adapted depending on whether participants were exercising together/providing support to a spouse or a friend/family member. For instance, people may feel they are a hindrance or that they need to return the favor if their friend comes over to cook dinner or childmind, as opposed to if their spouse does these tasks.

Shared goals may only promote PA in dyads who value interdependence with their partner. According to attachment theory, people high in attachment avoidance – distrusting others and fearing intimacy (Bartholomew, 1990) – may have lower transactive density from

finding each other's request for support intrusive (see, Fitzsimons et al., 2015). People who are high in attachment anxiety or feel insecure in their relationships may seek greater goal interdependence to promote intimacy (Fitzsimons et al., 2015). Future studies could measure how people feel about their partner asking for support, and strategies to help mitigate feeling of being imposing/imposed upon, qualitative research in this area could help explore these issues. Interventions that target increasing social self-efficacy (belief they can initiate social contact) and emotional awareness may be helpful for increasing levels of social support, and reducing distress, in people with high attachment avoidance (Mallinckrodt & Wei, 2005).

Participants selected an inactive partner, which sometimes meant they settled for their second choice of partner or someone of a similar low PA status. Future studies could explore whether greater PA is achieved through pairing an inactive individual with an active partner. It may be useful to pair participants with a physically active role model of a similar status who could serve as their inspiration (e.g. a physically active mother who balances PA with the demands of childcare). These role models could work with the participants to provide support and promote PA.

Finally, mothers, being time poor, may not readily engage with PA interventions. The mothers who signed up to join our study may not be reflective of the general population, as they may have been more motivated to fit PA around their childcare commitments. However, generalisability of the study was aided by recruiting through a variety of mediums including flyers, Facebook posts, and from family and parenting centres.

Conclusion

To our knowledge, this trial was the first dyadic PA intervention aimed at postpartum parent couples. With new responsibilities and lifestyle changes, postpartum mothers face a unique set of barriers to PA (Connolly et al., 2014). Although we showed that it is possible to recruit postpartum mothers and to a large extent their spouses, planning and motivation communication strategies had somewhat limited effects in increasing levels of PA and unexpected effects on motivation and confidence. We hope our results will inform future dyadic studies for PA promotion in couples with young children.

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Table 1

Characteristics of the Study Sample at Screening

	Control		Collaborative planning		Collaborative planning + need supportive communication	
	Actor	Partner	Actor	Partner	Actor	Partner
Relationships (dyads)						
Couple	14		16		13	
Friend	1		1		1	
Family (parent/parent-in-law/sibling)	2		2		1	
Age	34.76	37.81	33.88	38.64	35.22	40.26
Sex % female	100%	18%	100%	16%	100%	13%
Married or Defacto %	100%	94%	95%	90%	93%	93%
Breastfeed %	59%	n/a	58%	n/a	73%	n/a
Number of children (median)	2	2	1	1	2	2
Good social support networks for childcare %	65%	n/a	53%	n/a	60%	n/a
SES (median)	1029	1029	1006	1006	1000	1000
Education						
Less than high school	0%	0%	0%	0%	0%	7%
High school	24%	24%	11%	32%	0%	13%
Some college	12%	18%	11%	16%	20%	13%
Degree level	65%	59%	79%	53%	80%	67%

Table 2

Within-group Estimates of Actors' Total Physical Activity, Sedentary Time, and Psychosocial Outcomes, at Baseline, Post-intervention, and Follow-Up

	Baseline		Post-intervention		Follow-up		Effect size (Hedges' g_{av})		
	M	*SD*	*M*	*SD*	*M*	*SD*	Baseline-Post-intervention	Baseline-Follow-up	Post-intervention-Follow-up
Total Valid Days (mins/day)									
Control	7.35	1.17	7.23	1.54	7.46	1.13			
Collaborative planning	8.00	0.94	7.54	1.39	7.36	1.22			
Collaborative planning+need supportive communication	7.60	1.06	7.15	1.34	7.54	1.13			
Waking Wear Time (mins/day)									
Control	891.90	74.53	906.67	52.44	895.22	45.46			
Collaborative planning	909.48	51.60	887.28	52.75	918.31	57.02			
Collaborative planning+need supportive communication	882.15	71.04	893.63	42.87	879.73	60.40			
Total Physical Activity (mins/day)									
Control	416.97	98.11	382.86	110.44	431.01	103.32	0.31	0.13	0.43
Collaborative planning	394.61	94.89	395.99	70.02	446.89	97.85	0.02	0.52	0.57
Collaborative planning+need supportive communication	408.08	109.26	371.63	90.13	376.31	79.87	0.34	0.31	0.05
Sedentary Time (mins/day)									
Control	474.87	84.54	487.91	94.89	456.05	109.38	0.14	0.18	0.30
Collaborative planning	514.85	93.23	499.70	93.62	499.16	104.84	0.16	0.15	0.01
Collaborative planning+need supportive communication	474.05	76.51	515.08	104.22	510.44	82.40	0.42	0.43	0.05
Personal Autonomous Reasons (1-5)									
Control	3.90	0.61	3.99	0.38	4.13	0.40	0.17	0.43	0.35

Collaborative planning	3.65	0.78	3.60	0.84	3.61	0.86	0.06	0.04	0.02
Collaborative planning+need supportive communication	4.00	0.85	3.87	0.81	3.74	0.73	0.14	0.32	0.17
Relational Autonomous Reasons (1-5)									
Control	3.21	0.90	3.31	0.91	3.19	0.63	0.11	0.02	0.14
Collaborative planning	3.68	0.51	3.56	0.71	3.82	0.68	0.19	0.21	0.35
Collaborative planning+need supportive communication	3.42	1.09	3.30	0.78	3.28	0.95	0.12	0.12	0.01
Relational Controlled Reasons (1-5)									
Control	1.92	0.72	2.08	0.75	2.16	0.77	0.20	0.31	0.10
Collaborative planning	2.11	0.86	2.31	0.91	2.21	0.85	0.22	0.11	0.11
Collaborative planning+need supportive communication	2.27	0.92	2.22	0.98	2.12	0.87	0.04	0.15	0.10
Need Supportive Behaviours (1-7)									
Control	5.81	1.09	5.89	0.74	5.91	0.83	0.08	0.08	0.08
Collaborative planning	5.19	0.78	5.95	0.69	5.71	0.96	0.09	0.09	0.09
Collaborative planning+need supportive communication	5.61	1.07	5.48	1.24	5.52	0.94	0.02	0.02	0.02
Controlling Behaviours (1-7)									
Control	2.28	0.80	1.93	0.77	1.94	0.73	0.43	0.43	0.00
Collaborative planning	2.16	0.73	2.10	0.70	1.80	0.75	0.08	0.46	0.40
Collaborative planning+need supportive communication	1.94	0.79	2.08	0.91	2.15	0.87	0.15	0.24	0.08
Confidence in Partner to Support (1-5)									
Control	3.12	0.74	3.24	0.51	2.97	0.50	0.17	0.22	0.50
Collaborative planning	2.95	0.79	3.38	0.89	3.06	0.92	0.49	0.13	0.33
Collaborative planning+need supportive communication	3.55	1.05	3.09	0.94	3.30	1.03	0.43	0.23	0.19
Confidence in Partner to Exercise (1-5)									
Control	2.84	0.55	2.91	0.67	2.89	0.72	0.11	0.07	0.04
Collaborative planning	3.17	0.84	3.04	0.90	3.13	0.97	0.14	0.04	0.09
Collaborative planning+need supportive	3.55	0.88	3.63	0.82	3.58	0.98	0.09	0.03	0.05

communication									
Relation-inferred Self-Efficacy (1-5)									
Control	3.21	0.69	3.34	0.68	3.00	0.65	0.18	0.29	0.49
Collaborative planning	3.03	0.73	3.06	0.73	3.09	0.80	0.04	0.08	0.04
Collaborative planning+need supportive communication	3.28	0.68	3.23	0.66	3.36	0.79	0.07	0.10	0.17

Table 3

Within-group Estimates of Partners' Total Physical Activity, Sedentary Time, and Psychosocial Outcomes at Baseline, Post-intervention, and Follow-Up

	Baseline		Post-intervention		Follow-up		Effect size (Hedges' g_{av})		
							Baseline-Post-intervention	Baseline-Follow-up	Post-intervention-Follow-up
	M	*SD*	*M*	*SD*	*M*	*SD*			
Total Valid Days (mins/day)									
Control	7.44	1.31	7.91	1.70	7.91	0.83			
Collaborative planning	7.67	1.28	7.77	0.93	7.57	1.22			
Collaborative planning+need supportive communication	7.71	0.99	7.25	1.22	6.92	1.51			
Waking Wear Time (mins/day)									
Control	948.41	55.99	898.36	100.48	932.26	84.61			
Collaborative planning	928.15	90.39	937.90	60.85	933.96	70.56			
Collaborative planning+need supportive communication	909.91	61.22	890.76	77.17	886.88	85.17			
Total Physical Activity (mins/day)									
Control	403.21	128.50	397.60	170.48	402.23	116.15	0.04	0.01	0.03
Collaborative planning	377.57	101.26	379.44	113.23	365.37	91.19	0.02	0.12	0.13
Collaborative planning + need supportive communication	372.27	98.93	351.94	110.06	367.91	93.22	0.18	0.04	0.15
Sedentary Time (mins/day)									
Control	540.71	128.55	497.10	155.86	513.72	127.65	0.29	0.20	0.11
Collaborative planning	551.55	94.70	544.65	105.78	576.07	104.28	0.07	0.24	0.29
Collaborative planning+need supportive communication	536.44	81.23	534.25	70.34	510.41	78.28	0.03	0.31	0.30
Personal Autonomous Reasons (1-5)									
Control	3.77	0.52	3.90	0.52	4.00	0.60	0.25	0.40	0.17
Collaborative planning	3.41	1.02	3.49	0.67	3.72	0.90	0.09	0.31	0.28

Collaborative planning+need supportive communication	3.98	0.53	3.74	0.45	4.05	0.59	0.46	0.11	0.55
Relational Autonomous Reasons (1-5)									
Control	3.44	0.55	3.68	0.55	3.57	0.67	0.41	0.20	0.16
Collaborative planning	3.25	0.81	3.41	0.59	3.42	0.87	0.22	0.20	0.02
Collaborative planning+need supportive communication	3.48	0.79	3.41	1.02	3.23	1.11	0.07	0.25	0.16
Relational Controlled Reasons (1-5)									
Control	2.69	0.93	2.58	0.99	2.61	0.99	0.10	0.07	0.03
Collaborative planning	2.14	0.89	2.31	1.07	2.36	1.04	0.17	0.22	0.04
Collaborative planning+need supportive communication	2.13	0.81	2.07	0.81	2.18	0.63	0.07	0.06	0.14
Need Supportive Behaviours (1-7)									
Control	5.39	1.13	5.98	0.72	5.69	1.05	0.60	0.27	0.31
Collaborative planning	5.95	0.59	5.92	0.55	5.88	0.51	0.06	0.02	0.09
Collaborative planning+need supportive communication	5.89	0.69	5.78	1.10	5.81	0.85	0.11	0.10	0.03
Controlling Behaviours (1-7)									
Control	2.74	1.08	2.35	0.80	3.09	1.32	0.38	0.28	0.65
Collaborative planning	2.31	0.97	2.59	1.12	2.65	1.06	0.26	0.33	0.05
Collaborative planning+need supportive communication	2.17	0.72	2.11	0.52	0.68	2.04	0.09	0.17	0.10
Confidence in Partner to Support (1-5)									
Control	3.13	0.72	3.16	0.75	3.45	0.85	0.04	0.38	0.34
Collaborative planning	3.45	0.75	3.39	0.79	3.38	0.96	0.08	0.07	0.01
Collaborative planning+need supportive communication	3.35	0.64	3.17	0.63	2.89	0.83	0.27	0.59	0.36
Confidence in Partner to Exercise (1-5)									
Control	3.27	0.69	3.33	0.73	3.42	0.86	0.09	0.19	0.10
Collaborative planning	3.38	0.89	3.45	1.02	3.42	0.85	0.07	0.04	0.03
Collaborative planning+need supportive communication	3.00	0.56	2.89	0.76	2.66	0.83	0.15	0.45	0.27

Relation-inferred Self-Efficacy (1-5)									
Control	3.03	0.57	3.20	0.61	3.04	0.95	0.28	0.01	0.20
Collaborative planning	3.11	0.80	3.05	0.64	3.07	0.66	0.07	0.04	0.03
Collaborative planning+need supportive communication	3.13	0.75	3.30	0.50	2.99	0.66	0.24	0.20	0.51

Table 4

Intervention Effects at Post-Intervention on Total Physical Activity for Actors and Partners

	Model A Priors: noninformative			Model B Priors: *M* = 15, *SD* = 15			Model C Priors: *M* = 15, SD = 7.5			Model D Priors: *M* = 30, *SD* = 30			Model E Priors: *M* = 30, *SD* = 15		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects															
ActorT1→ActorT2	0.61*	0.31	0.90	0.59*	0.29	0.88	0.59*	0.29	0.88	0.59*	0.29	0.88	0.58*	0.27	0.88
PartnerT1→ActorT2	0.17	-0.06	0.40	0.18	-0.05	0.41	0.18	-0.05	0.41	0.17	-0.06	0.40	0.18	-0.06	0.41
Collaborative planning→ActorT2[a]	-2.82	-57.24	51.44	15.49	-9.53	40.51	15.54*	1.55	29.54	20.61	-17.25	59.84	28.37*	3.20	53.73
Collaborative planning+need supportive communication→ActorT2[a]	-27.05	-78.56	24.35	4.14	-20.24	29.29	11.39	-2.53	25.49	0.77	-35.43	39.26	16.93	-7.74	42.49
Wear-time	0.14	-0.28	0.56	0.19	-0.23	0.60	0.19	-0.22	0.61	0.18	-0.23	0.60	0.21	-0.22	0.63
Age	1.55	-3.73	6.82	1.47	-3.77	6.69	1.40	-3.89	6.66	1.58	-3.70	6.84	1.51	-3.86	6.84
SES	-0.20	-0.60	0.21	-0.13	-0.52	0.26	-0.11	-0.50	0.28	-0.14	-0.54	0.26	-0.11	-0.51	0.29
Social support	-34.35	-81.69	12.97	-36.26	-81.82	8.89	-38.03	-83.20	7.01	-33.64	-80.18	12.82	-34.93	-81.47	11.22
Breastfeeding	11.85	-28.91	52.72	7.34	-32.90	47.45	6.52	-33.90	46.88	7.56	-33.27	47.91	5.29	-35.85	46.23
Number of children	2.87	-50.24	56.22	-0.17	-50.29	49.65	-2.72	-52.10	46.48	3.41	-48.47	55.27	1.16	-50.29	52.31
Partner effects															
PartnerT1→PartnerT2	0.66*	0.29	1.03	0.64*	0.28	1.00	0.64*	0.28	1.00	0.63*	0.26	1.00	0.63*	0.26	0.99
ActorT1→PartnerT2	0.10	-0.32	0.52	0.05	-0.36	0.45	0.04	-0.36	0.44	0.05	-0.37	0.46	0.03	-0.38	0.44
Collaborative planning→PartnerT2[a]	-34.62	-120.83	51.96	9.64	-17.58	37.11	13.44	-0.96	27.84	12.07	-34.42	60.01	23.95	-3.33	51.54
Collaborative planning+need supportive communication→PartnerT2[a]	-8.58	84.73	69.36	15.50	-11.48	42.31	15.37*	0.98	29.65	24.24	-20.61	69.89	29.61*	2.50	56.56
Wear-time	0.58*	0.08	1.10	0.50*	0.05	0.94	0.48*	0.05	0.91	0.53*	0.05	0.99	0.50*	0.05	0.95
Age	-3.60	-7.61	0.37	-3.44	-7.32	0.44	-3.37	-7.26	0.50	-3.54	-7.50	0.42	-3.43	-7.37	0.50
SES	-0.21	-0.79	0.37	-0.13	-0.68	0.43	-0.12	-0.67	0.44	-0.13	-0.69	0.45	-0.10	-0.67	0.47
Number of children	-44.62	-122.51	31.57	-31.88	-99.50	34.71	-29.49	-95.25	35.34	-34.90	-106.62	36.01	-31.00	-99.90	36.80
	r									*r*			*r*		
ActorT1↔PartnerT1	0.51*	0.23	0.71	0.52*	0.24	0.71	0.52	0.24	0.72	0.52*	0.24	0.71	0.52*	0.24	0.72
ActorT2↔PartnerT2	0.29	-0.11	0.60	0.29	-0.10	0.60	0.28	-0.10	0.59	0.30	-0.09	0.61	0.32	-0.07	0.62
PPP value	0.39 [-33.31, 43.08]			0.42 [-33.85, 41.64]			0.41 [-33.57, 42.12]			0.40 [-33.29, 42.70]			0.39 [-32.28, 43.65]		
DIC	2906			2902			2902			2904			2905		

Note. [a]priors placed on the regression coefficients. *denotes a 95% CI excluding zero. PPP value = posterior predictive *p* value, DIC = deviance information criterion

Table 5

Intervention Effects at Follow-Up on Total Physical Activity for Actors and Partners

	Model F Priors: noninformative			Model G Priors: *M* = 15, *SD* = 15			Model H Priors: *M* = 15, SD = 7.5			Model I Priors: *M* = 30, *SD* = 30			Model J Priors: *M* = 30, *SD* = 15		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects															
ActorT1→ActorT2	0.64*	0.33	0.94	0.63*	0.32	0.94	0.63*	0.31	0.94	0.63*	0.32	0.94	0.63*	0.31	0.94
PartnerT1→ActorT2	0.12	-0.15	0.39	0.15	-0.11	0.41	0.16	-0.10	0.43	0.13	-0.13	0.40	0.15	-0.11	0.42
Collaborative planning→ActorT2[a]	28.44	-34.86	92.03	21.47	-4.82	47.44	17.15*	2.86	31.40	36.41	-4.89	77.76	34.62*	8.36	60.67
Collaborative planning+need supportive communication→ActorT2[a]	-20.30	-78.80	38.00	4.72	-20.67	30.56	11.67	-2.42	25.89	2.47	-36.44	43.09	17.46	-8.10	43.56
Wear-time	0.38	-0.10	0.86	0.44	-0.03	0.91	0.46	-0.01	0.94	0.41	-0.06	0.89	0.44	-0.03	0.92
Age	-1.15	-7.91	5.61	-1.73	-8.41	4.86	-1.96	-8.68	4.72	-1.35	-8.03	5.27	-1.63	-8.39	5.03
SES	0.10	-0.36	0.57	0.13	-0.32	0.59	0.14	-0.32	0.60	0.13	-0.32	0.59	0.15	-0.31	0.61
Social support	-21.03	-79.80	37.16	-27.81	-83.09	26.54	-30.31	-85.54	24.46	-21.65	-77.83	33.85	-24.62	-80.58	30.49
Breastfeeding	-34.75	-83.64	14.55	-38.47	-85.78	8.89	-39.33	-86.99	8.58	-38.94	-86.63	8.63	-41.38	-89.23	6.43
Number of children	19.94	-36.41	75.76	14.68	-39.62	68.24	12.56	-41.74	66.55	19.02	-35.77	73.11	16.48	-38.41	70.74
Partner effects															
PartnerT1→PartnerT2	0.68*	0.44	0.92	0.67*	0.43	0.91	0.67*	0.42	0.91	0.68*	0.44	0.92	0.68*	0.43	0.92
ActorT1→PartnerT2	0.02	-0.31	0.34	0.01	-0.32	0.33	0.01	-0.33	0.34	0.00	-0.33	0.33	0.00	-0.34	0.33
Collaborative planning→PartnerT2[a]	-39.62	-105.11	26.34	3.63	-22.64	30.49	11.60	-2.65	25.95	-2.05	-43.94	42.14	17.16	-9.32	44.24
Collaborative planning+need supportive communication →PartnerT2[a]	10.76	-52.99	74.79	18.95	-7.27	44.95	16.39*	2.12	30.62	29.91	-11.51	72.09	32.22*	5.93	58.41
Wear-time	0.35*	0.00	0.70	0.28	-0.05	0.61	0.26	-0.07	0.59	0.32	-0.02	0.66	0.29	-0.05	0.62
Age	-1.64	-5.56	2.24	-2.04	-5.93	1.80	-2.10	-6.03	1.80	-2.04	-5.96	1.80	-2.21	-6.19	1.71
SES	-0.26	-0.69	0.18	-0.22	-0.66	0.22	-0.21	-0.65	0.24	-0.22	-0.66	0.22	-0.21	-0.65	0.25
Number of children	-22.27	-80.83	36.08	-4.42	-57.97	50.23	0.11	-53.35	53.95	-10.23	-65.60	46.74	-1.90	-56.61	53.94
ActorT1↔PartnerT1	0.51*	0.23	0.71	0.52	0.24	0.71	0.52	0.24	0.71	0.51*	0.24	0.71	0.52*	0.24	0.71
ActorT2↔PartnerT2	0.10	-0.28	0.46	0.07	-0.30	0.42	0.04	-0.32	0.39	0.11	-0.27	0.46	0.09	-0.28	0.44
PPP value	0.45 [-35.54, 38.66]			0.45 [-35.12, 38.59]			0.42 [-33.59, 40.21]			0.45 [-35.37, 38.61]			0.42 [-33.59, 40.48]		
DIC	2961			2958			2960			2959			2961		

Note. [a]priors placed on the regression coefficients. *denotes a 95% CI excluding zero. PPP value = posterior predictive *p* value DIC = deviance information criterion.

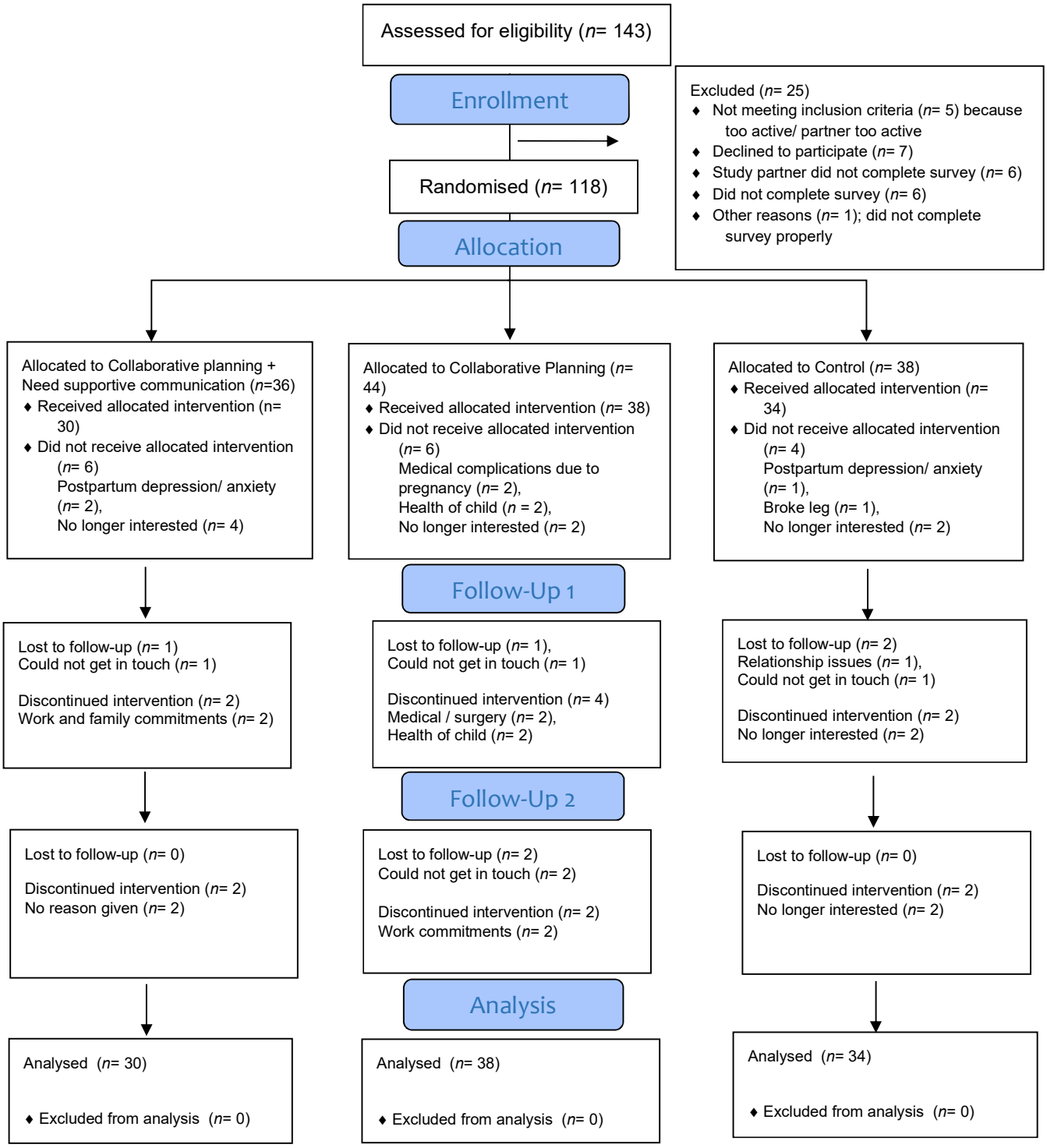

Figure 1. Flow diagram to show participant numbers throughout the study

Note. This list is not exhaustive; it includes the main reason for exclusion of each participant, but multiple criteria may have applied to one participant. Reasons for exclusion can apply to the participant, their partner or both. Numbers are based on the self-report data, as this was the minimum for participants to continue the study. The number of participants with valid accelerometer data is Control *T1*=33, *T2*=24, *T3*=24; collaborative planning *T1*=37, *T2*=26, *T3*=28; Collaborative planning + need supportive communication *T1*=29, *T2*=25, *T3*=25.

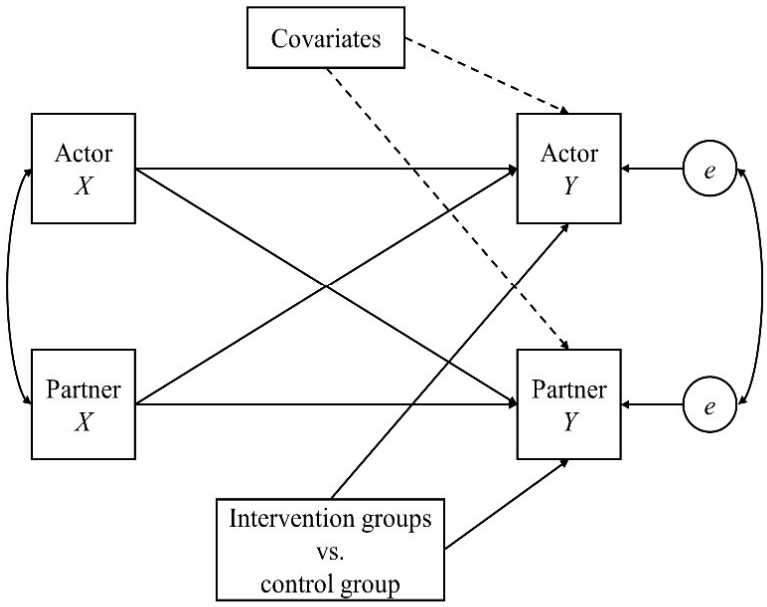

Figure 2. The actor-partner interdependence model. *X* and *Y* indicate measured variables and *e* denotes residual variance.

Supplementary Material

Table S1

Cronbach's Alphas for Each Subscale

Time points	Baseline		Post-intervention		Follow-up	
Measures	Actor	Partner	Actor	Partner	Actor	Partner
Personal autonomous reasons	.74	.80	.78	.70	.76	.85
Personal controlled reasons	.15	.04	-.60	.28	.14	.50
Relational autonomous reasons	.84	.72	.81	.86	.85	.85
Relational controlled reasons	.68	.74	.74	.85	.76	.71
Need supportive behaviours	.94	.93	.94	.89	.92	.93
Controlling behaviours	.67	.85	.67	.76	.65	.78
Confidence in partner to support	.95	.91	.93	.94	.95	.91
Confidence in partner to exercise	.90	.94	.94	.96	.95	.97
Relation-inferred self-efficacy	.91	.92	.93	.92	.96	.94

Table S2

Within-Group Estimates of Physical Activity and Baseline, Post-intervention, and Follow-Up Comparisons for Actors

	Baseline		Post-intervention		Follow-up		Effect size (Hedges' g_{av})		
	M	*SD*	*M*	*SD*	*M*	*SD*	Baseline-Post-intervention	Baseline-Follow-up	Post-intervention-Follow-up
Light Physical Activity (mins/day)									
Control	376.26	79.69	368.93	84.14	378.27	76.51	0.09	0.02	0.11
Collaborative planning	340.70	110.66	375.58	63.87	427.29	99.12	0.37	0.79	0.59
Collaborative planning + need supportive communication	366.06	95.90	339.71	86.74	342.75	73.13	0.27	0.26	0.04
Moderate Physical Activity (mins/day)									
Control	40.07	25.92	35.10	20.32	49.38	32.43	0.20	0.30	0.50
Collaborative planning	53.70	72.22	40.70	28.93	43.73	18.35	0.23	0.18	0.12
Collaborative planning + need supportive communication	41.31	21.69	30.99	14.50	35.28	20.08	0.53	0.27	0.23
Vigorous Physical Activity (mins/day)									
Control	0.64	1.28	0.58	1.78	1.81	2.84	0.04	0.50	0.49
Collaborative planning	0.21	0.24	0.81	1.26	0.24	0.59	0.64	0.08	0.55
Collaborative planning + need supportive communication	0.71	1.18	2.08	2.75	0.83	1.58	0.61	0.08	0.53
MVPA (mins/day)									
Control	40.71	26.82	36.22	21.01	51.26	34.09	0.18	0.33	0.51
Collaborative planning	53.91	72.20	41.77	30.48	45.33	19.87	0.21	0.16	0.13
Collaborative planning + need supportive communication	42.01	22.10	33.14	16.42	36.17	21.25	0.43	0.25	0.15

Note. MVPA = moderate-vigorous physical activity

Table S3

Within-Group Estimates of Physical Activity and Baseline, Post-intervention, and Follow-Up Comparisons for Partners

	Baseline		Post-intervention		Follow-up		Effect size (Hedges' g_{av})		
	M	*SD*	*M*	*SD*	*M*	*SD*	Baseline-Post-intervention	Baseline-Follow-up	Post-intervention-Follow-up
Light Physical Activity (mins/day)									
Control	328.87	34.27	327.73	55.45	329.01	72.08	0.02	0.00	0.02
Collaborative planning	329.98	86.40	329.12	95.18	309.15	62.91	0.01	0.26	0.24
Collaborative planning + need supportive communication	330.23	82.34	305.71	90.45	321.76	73.81	0.27	0.10	0.18
Moderate Physical Activity (mins/day)									
Control	52.50	48.44	65.86	69.90	54.21	61.11	0.21	0.03	0.17
Collaborative planning	46.21	26.72	48.23	28.74	51.02	34.04	0.07	0.15	0.08
Collaborative planning + need supportive communication	41.01	22.69	40.94	26.22	42.48	39.94	0.00	0.04	0.04
Vigorous Physical Activity (mins/day)									
Control	0.84	2.11	0.77	0.99	0.26	1.64	0.04	0.30	0.36
Collaborative planning	1.19	1.59	2.11	2.32	2.00	2.03	0.44	0.42	0.05
Collaborative planning + need supportive communication	1.03	1.58	1.40	2.26	1.25	3.62	0.18	0.07	0.05
MVPA (mins/day)									
Control	53.46	49.59	66.99	71.14	54.72	62.09	0.21	0.02	0.18
Collaborative planning	47.34	27.65	50.60	30.36	52.85	34.41	0.11	0.17	0.07
Collaborative planning + need supportive communication	42.04	23.00	42.35	27.49	43.86	40.96	0.01	0.05	0.04

Note. MVPA = moderate-vigorous physical activity

Table S4

Sedentary Time

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.481*	0.122	0.843	0.724*	0.382	1.062
PartnerT1 → ActorT2	0.351*	0.095	0.601	0.266*	0.012	0.518
Collaborative planning → ActorT2	-7.293	-62.697	48.708	-15.105	-73.342	43.927
Collaborative planning+need supportive communication → ActorT2	52.454	-1.964	107.775	50.373	-3.667	104.938
Wear-time	0.630*	0.196	1.069	0.426	-0.007	0.860
Age	-4.382	-9.548	0.684	-0.094	-5.958	5.777
SES	0.093	-0.320	0.507	-0.161	-0.595	0.265
Social support	47.308*	0.732	93.980	48.972	-1.275	98.780
Breastfeeding	-18.201	-61.378	24.518	15.393	-29.699	60.423
Number of children	-8.778	-62.743	44.684	-19.479	-68.292	30.632
Partner effects						
PartnerT1 → PartnerT2	0.805*	0.435	1.173	0.782*	0.494	1.067
ActorT1 → PartnerT2	-0.151	-0.613	0.311	-0.283	-0.685	0.113
Collaborative planning → PartnerT2	50.323	-34.444	134.548	50.186	-20.459	120.504
Collaborative planning+need supportive communication → PartnerT2	33.278	-44.644	110.706	-2.698	-70.999	66.024
Wear-time	0.068	-0.392	0.523	0.350	-0.009	0.711
Age	5.091*	1.171	8.965	3.657	-0.501	7.828
SES	0.088	-0.455	0.633	0.084	-0.394	0.567
Number of children	52.792	-21.683	127.023	30.608	-32.038	93.678
	r			*r*		
ActorT1 ↔ PartnerT1	0.482*	0.209	0.682	0.476*	0.206	0.675
ActorT2 ↔ PartnerT2	0.288	-0.129	0.614	0.284	-0.132	0.608
Posterior predictive *p* value	0.579 [-42.672, 33.864]			0.535 [-39.902, 34.811]		

Note. *denotes a 95% CI excluding zero

Table S5

Light Physical Activity

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.402*	0.165	0.640	0.479*	0.248	0.709
PartnerT1 → ActorT2	0.256	-0.016	0.526	0.165	-0.102	0.435
Collaborative planning → ActorT2	17.877	-36.909	72.561	45.673	-9.352	100.916
Collaborative planning+need supportive communication→ ActorT2	-17.482	-69.149	33.898	-10.300	-60.568	39.801
Wear-time	0.357	-0.061	0.771	0.350	-0.068	0.770
Age	1.778	-3.255	6.842	-0.296	-6.112	5.523
SES	-0.064	-0.470	0.340	0.199	-0.196	0.592
Social support	-44.355	-92.379	3.850	-23.126	-73.795	27.299
Breastfeeding	13.129	-28.043	54.534	-30.186	-72.800	12.617
Number of children	3.526	-50.647	57.653	21.976	-27.524	71.156
Partner effects						
PartnerT1 → PartnerT2	0.630*	0.277	0.980	0.569*	0.360	0.774
ActorT1 → PartnerT2	0.103	-0.172	0.380	0.015	-0.181	0.212
Collaborative planning → PartnerT2	-25.896	-91.915	40.345	-27.371	-74.169	19.694
Collaborative planning+need supportive communication → PartnerT2	-7.020	-67.641	54.534	8.445	-36.338	53.235
Wear-time	0.502*	0.096	0.906	0.212	-0.032	0.456
Age	-2.614	-5.790	0.536	-1.534	-4.346	1.257
SES	-0.139	-0.594	0.318	-0.141	-0.453	0.170
Number of children	-42.090	-103.229	17.970	-13.771	-55.555	28.075
	r			*r*		
ActorT1 ↔ PartnerT1	0.332*	0.025	0.579	0.335*	0.031	0.580
ActorT2 ↔ PartnerT2	0.255	-0.156	0.589	0.014	-0.356	0.384
Posterior predictive *p* value	0.419 [-34.217, 40.952]			0.447 [-35.431, 38.585]		

Note. *denotes a 95% CI excluding zero

Table S6

Moderate Physical Activity

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.050	-0.071	0.171	-0.007	-0.131	0.125
PartnerT1 → ActorT2	0.235*	0.040	0.426	0.434*	0.209	0.640
Collaborative planning → ActorT2	-3.643	-19.956	12.575	-6.959	-24.424	10.259
Collaborative planning+need supportive communication → ActorT2	-6.930	-22.123	8.263	-8.452	-25.184	7.789
Wear-time	-0.045	-0.180	0.090	0.035	-0.095	0.163
Age	1.824*	0.407	3.250	0.377	-1.354	2.176
SES	-0.125*	-0.244	-0.004	-0.111	-0.243	0.017
Social support	-3.068	-16.768	10.625	-8.970	-24.004	6.300
Breastfeeding	-1.401	-13.752	10.915	-0.877	-14.501	12.504
Number of children	-4.818	-20.149	10.353	5.144	-10.297	19.998
Partner effects						
PartnerT1 → PartnerT2	0.973*	0.735	1.206	1.092*	0.860	1.322
ActorT1 → PartnerT2	-0.052	-0.188	0.081	0.004	-0.165	0.171
Collaborative planning → PartnerT2	-4.387	-24.705	16.357	-7.693	-31.836	16.576
Collaborative planning+need supportive communication → PartnerT2	-3.876	-21.646	14.260	7.416	-15.361	30.248
Wear-time	0.052	-0.060	0.166	0.131*	0.012	0.253
Age	-0.742	-1.746	0.240	-0.010	-1.389	1.342
SES	-0.100	-0.232	0.032	-0.090	-0.247	0.064
Number of children	5.540	-12.747	23.890	-5.572	-26.564	15.240
	r			*r*		
ActorT1 ↔ PartnerT1	0.129	-0.164	0.402	0.155	-0.138	0.423
ActorT2 ↔ PartnerT2	-0.064	-0.476	0.366	0.190	-0.259	0.572
Posterior predictive *p* value	0.575 [-42.608, 34.036]			0.531 [-39.285, 34.564]		

Note. *denotes a 95% CI excluding zero

Table S7

Vigorous Physical Activity

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			*95% CI*	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects (continuous part)						
ActorT1 → ActorT2	0.021	-0.032	0.075	0.039*	0.000	0.078
PartnerT1 → ActorT2	0.005	-0.029	0.039	-0.018	-0.043	0.009
Collaborative planning → ActorT2	-0.017	-2.928	2.851	-0.937	-2.662	0.739
Collaborative planning+need supportive communication → ActorT2	0.598	-2.944	4.106	-0.237	-1.857	1.375
Wear-time	0.001	-0.032	0.033	0.003	-0.013	0.019
Age	0.049	-0.188	0.291	-0.115	-0.287	0.057
SES	-0.002	-0.019	0.016	-0.002	-0.018	0.015
Social support	0.396	-1.868	2.644	0.353	-1.254	1.952
Breastfeeding	1.069	-0.958	3.106	0.832	-0.488	2.149
Number of children	-0.580	-3.039	1.870	0.830	-0.978	2.584
Actor effects (binary part)						
ActorT1 → ActorT2	-0.004	-0.019	0.006	-0.005	-0.021	0.004
PartnerT1 → ActorT2	0.011	-0.003	0.026	0.013	-0.005	0.033
Collaborative planning → ActorT2	0.282	-0.870	1.425	-0.460	-1.692	0.730
Collaborative planning+need supportive communication → ActorT2	-0.540	-1.582	0.486	-0.061	-1.095	0.963
Wear-time	-0.001	-0.007	0.006	0.006	-0.002	0.014
Age	0.126*	0.006	0.261	0.011	-0.114	0.133
SES	-0.003	-0.010	0.004	-0.006	-0.013	0.001
Social support	0.248	-0.682	1.207	-0.383	-1.406	0.627
Breastfeeding	-0.472	-1.348	0.392	-0.305	-1.237	0.599
Number of children	-0.112	-1.174	0.934	0.253	-0.726	1.242
Partner effects (continuous part)						
PartnerT1 → PartnerT2	0.004	-0.017	0.026	0.013	-0.005	0.031
ActorT1 → PartnerT2	-0.010	-0.045	0.025	-0.008	-0.019	0.002
Collaborative planning → PartnerT2	1.666	-0.676	4.008	1.991	-0.001	4.015
Collaborative planning+need supportive communication → PartnerT2	0.749	-1.218	2.719	0.825	-1.100	2.776
Wear-time	-0.004	-0.018	0.011	-0.002	-0.011	0.007
Age	-0.111	-0.246	0.025	0.013	-0.119	0.145
SES	-0.003	-0.016	0.009	0.001	-0.010	0.012
Number of children	0.428	-1.500	2.383	0.813	-0.598	2.240
Partner effects (binary part)						
PartnerT1 → PartnerT2	0.031*	0.008	0.059	0.065*	0.013	0.134
ActorT1 → PartnerT2	-0.006	-0.022	0.004	0.066*	0.011	0.136
Collaborative planning → PartnerT2	0.357	-1.116	1.828	-0.287	-2.672	1.940
Collaborative planning+need supportive communication → PartnerT2	0.462	-0.770	1.700	3.679*	1.451	6.816
Wear-time	-0.001	-0.008	0.006	0.002	-0.007	0.011
Age	-0.073*	-0.168	-0.001	-0.120	-0.322	0.034
SES	0.001	-0.005	0.007	0.000	-0.008	0.008
Number of children	0.619	-0.497	1.737	-0.029	-1.865	1.711
	r			*r*		
ActorT1 ↔ PartnerT1	0.119	-0.158	0.378	0.129	-0.149	0.388
ActorT2 ↔ PartnerT2 (continuous part)	0.001	-0.644	0.668	0.186	-0.486	0.714
ActorT2 ↔ PartnerT2 (binary part)	0.902*	0.362	0.979	-0.940	-0.982	-0.648
Posterior predictive *p* value	0.580 [-54.104, 42.784]			0.543 [-50.753, 43.255]		

Note. *denotes a 95% CI excluding zero

Table S8

Moderate and Vigorous Physical Activity

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.054	-0.070	0.177	-0.002	-0.133	0.136
PartnerT1 → ActorT2	0.245*	0.050	0.437	0.432*	0.203	0.642
Collaborative planning → ActorT2	-4.564	-21.208	12.007	-8.220	-26.591	9.888
Collaborative planning+need supportive communication → ActorT2	-6.570	-22.089	8.972	-9.034	-26.640	8.047
Wear-time	-0.046	-0.185	0.092	0.035	-0.102	0.169
Age	1.992*	0.548	3.449	0.347	-1.471	2.233
SES	-0.134*	-0.256	-0.010	-0.116	-0.254	0.020
Social support	-3.404	-17.381	10.570	-9.512	-25.302	6.536
Breastfeeding	-0.478	-13.098	12.107	-0.457	-14.771	13.583
Number of children	-5.987	-21.653	9.503	5.355	-10.871	20.971
Partner effects						
PartnerT1 → PartnerT2	0.960*	0.712	1.203	1.083*	0.853	1.313
ActorT1 → PartnerT2	-0.060	-0.203	0.080	0.002	-0.169	0.172
Collaborative planning → PartnerT2	-3.061	-24.529	18.870	-7.072	-31.584	17.540
Collaborative planning+need supportive communication → PartnerT2	-3.137	-21.912	16.056	8.226	-14.891	31.386
Wear-time	0.056	-0.063	0.176	0.134*	0.012	0.257
Age	-0.848	-1.912	0.193	-0.014	-1.414	1.360
SES	-0.111	-0.251	0.028	-0.091	-0.250	0.065
Number of children	6.035	-13.316	25.436	-5.585	-26.911	15.561
	r			*r*		
ActorT1 ↔ PartnerT1	0.135	-0.159	0.407	0.163	-0.131	0.430
ActorT2 ↔ PartnerT2	-0.081	-0.487	0.347	0.195	-0.255	0.575
Posterior predictive *p* value	0.575 [-42.636, 33.981]			0.530 [-39.314, 34.718]		

Note. *denotes a 95% CI excluding zero

Table S9

Personal Autonomous Reasons

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.665*	0.407	0.921	0.706*	0.512	0.901
PartnerT1 → ActorT2	-0.023	-0.297	0.250	0.096	-0.125	0.318
Collaborative planning → ActorT2	-0.199	-0.673	0.276	-0.269	-0.645	0.109
Collaborative planning+need supportive communication → ActorT2	-0.147	-0.602	0.314	-0.501*	-0.857	-0.146
Age	-0.009	-0.054	0.036	-0.014	-0.048	0.021
SES	0.001	-0.003	0.004	0.002	-0.001	0.004
Social support	0.008	-0.358	0.373	0.079	-0.211	0.371
Breastfeeding	0.020	-0.348	0.389	0.083	-0.210	0.372
Number of children	0.095	-0.340	0.532	0.069	-0.267	0.409
Partner effects						
PartnerT1 → PartnerT2	0.313	0.033	0.599	0.336*	0.054	0.620
ActorT1 → PartnerT2	0.087	-0.156	0.329	0.308*	0.053	0.560
Collaborative planning → PartnerT2	-0.392	-0.879	0.102	-0.227	-0.730	0.276
Collaborative planning+need supportive communication → PartnerT2	-0.235	-0.690	0.222	-0.053	-0.529	0.421
Age	-0.009	-0.034	0.017	0.005	-0.021	0.032
SES	0.001	-0.002	0.005	0.004	0.000	0.007
Number of children	-0.356	-0.749	0.038	-0.158	-0.578	0.262
	r			*r*		
ActorT1 ↔ PartnerT1	0.291*	0.007	0.532	0.292*	0.007	0.532
ActorT2 ↔ PartnerT2	0.422*	0.082	0.670	0.327	-0.016	0.602
Posterior predictive *p* value	0.296 [-21.750, 35.802]			0.360 [-24.984, 33.377]		

Note. *denotes a 95% CI excluding zero

Table S10

Relational Autonomous Reasons

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.554*	0.295	0.812	0.453*	0.192	0.715
PartnerT1 → ActorT2	-0.168	-0.461	0.125	0.260	-0.055	0.573
Collaborative planning → ActorT2	0.042	-0.518	0.604	0.422	-0.171	1.014
Collaborative planning+need supportive communication → ActorT2	-0.073	-0.601	0.458	-0.174	-0.716	0.367
Age	0.010	-0.038	0.058	0.030	-0.021	0.080
SES	0.002	-0.002	0.006	0.001	-0.003	0.005
Social support	0.151	-0.265	0.565	0.264	-0.178	0.711
Breastfeeding	-0.023	-0.442	0.394	-0.029	-0.484	0.420
Number of children	0.159	-0.360	0.673	-0.221	-0.747	0.304
Partner effects						
PartnerT1 → PartnerT2	0.557*	0.213	0.902	0.533*	0.130	0.939
ActorT1 → PartnerT2	0.059	-0.229	0.340	0.314	-0.017	0.639
Collaborative planning → PartnerT2	-0.157	-0.784	0.494	-0.262	-1.023	0.507
Collaborative planning+need supportive communication → PartnerT2	-0.096	-0.697	0.525	-0.402	-1.117	0.314
Age	-0.006	-0.038	0.026	-0.006	-0.045	0.033
SES	0.000	-0.004	0.005	-0.001	-0.006	0.005
Number of children	-0.414	-0.955	0.140	-0.077	-0.728	0.569
	r			*r*		
ActorT1 ↔ PartnerT1	-0.032	-0.313	0.255	-0.032	-0.314	0.254
ActorT2 ↔ PartnerT2	0.493*	0.140	0.725	0.383*	0.047	0.641
Posterior predictive *p* value	0.655 [-34.747, 21.938]			0.643 [-35.384, 22.778]		

Note. *denotes a 95% CI excluding zero

Table S11

Relational Controlled Reasons

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.455*	0.129	0.779	0.608*	0.292	0.925
PartnerT1 → ActorT2	0.221	-0.094	0.537	-0.024	-0.338	0.290
Collaborative planning → ActorT2	0.006	-0.664	0.680	-0.266	-0.909	0.378
Collaborative planning+need supportive communication→ ActorT2	0.103	-0.574	0.785	-0.154	-0.808	0.498
Age	0.010	-0.065	0.086	-0.019	-0.083	0.044
SES	0.000	-0.005	0.005	0.000	-0.004	0.005
Social support	0.036	-0.583	0.651	0.089	-0.490	0.668
Breastfeeding	-0.284	-0.840	0.273	-0.285	-0.825	0.249
Number of children	-0.541	-1.193	0.108	-0.453	-1.046	0.143
Partner effects						
PartnerT1 → PartnerT2	0.557*	0.199	0.914	0.602*	0.275	0.931
ActorT1 → PartnerT2	-0.062	-0.424	0.301	0.038	-0.285	0.359
Collaborative planning → PartnerT2	-0.045	-0.832	0.743	0.043	-0.650	0.737
Collaborative planning+need supportive communication → PartnerT2	-0.240	-1.046	0.564	-0.031	-0.735	0.675
Age	-0.025	-0.069	0.020	-0.008	-0.046	0.030
SES	0.001	-0.005	0.006	0.002	-0.003	0.007
Number of children	-0.211	-0.873	0.456	-0.211	-0.798	0.377
	r			*r*		
ActorT1 ↔ PartnerT1	-0.076	-0.352	0.214	-0.075	-0.353	0.213
ActorT2 ↔ PartnerT2	0.031	-0.377	0.425	0.001	-0.368	0.366
Posterior predictive *p* value	0.143 [-14.316, 45.945]			0.429 [-27.550, 30.854]		

Note. *denotes a 95% CI excluding zero

Table S12

Need Supportive Behaviours

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.649*	0.307	0.989	0.340*	0.010	0.671
PartnerT1 → ActorT2	-0.175	-0.581	0.233	0.343	-0.028	0.712
Collaborative planning → ActorT2	0.222	-0.426	0.874	-0.082	-0.625	0.462
Collaborative planning+need supportive communication → ActorT2	-0.111	-0.757	0.542	-0.426	-0.965	0.115
Age	-0.013	-0.073	0.047	0.018	-0.033	0.068
SES	-0.001	-0.006	0.003	-0.001	-0.005	0.002
Social support	0.179	-0.344	0.700	0.184	-0.278	0.645
Breastfeeding	0.080	-0.390	0.555	-0.068	-0.476	0.339
Number of children	0.104	-0.471	0.681	0.273	-0.215	0.764
Partner effects						
PartnerT1 → PartnerT2	0.561*	0.209	0.911	0.462*	0.095	0.828
ActorT1 → PartnerT2	-0.027	-0.329	0.280	0.127	-0.195	0.446
Collaborative planning → PartnerT2	-0.272	-0.789	0.255	0.103	-0.446	0.650
Collaborative planning+need supportive communication → PartnerT2	-0.308	-0.839	0.228	0.051	-0.513	0.617
Age	0.005	-0.023	0.032	0.023	-0.007	0.052
SES	0.001	-0.002	0.005	0.002	-0.002	0.006
Number of children	0.123	-0.317	0.561	0.122	-0.349	0.592
	r			*r*		
ActorT1 ↔ PartnerT1	0.625*	0.415	0.772	0.626*	0.415	0.773
ActorT2 ↔ PartnerT2	0.272	-0.099	0.573	0.080	-0.286	0.424
Posterior predictive *p* value	0.326 [-22.605, 34.474]			0.337 [-24.110, 33.979]		

Note. *denotes a 95% CI excluding zero

Table S13

Controlling Behaviours

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.645*	0.333	0.955	0.235	-0.149	0.622
PartnerT1 → ActorT2	0.029	-0.209	0.266	0.034	-0.236	0.305
Collaborative planning → ActorT2	0.402	-0.187	0.989	-0.028	-0.700	0.646
Collaborative planning+need supportive communication → ActorT2	0.321	-0.265	0.906	0.285	-0.364	0.937
Age	-0.002	-0.057	0.053	0.006	-0.060	0.073
SES	-0.002	-0.007	0.002	-0.001	-0.006	0.004
Social support	0.439	-0.084	0.960	-0.483	-1.047	0.084
Breastfeeding	0.124	-0.342	0.592	-0.221	-0.760	0.316
Number of children	0.219	-0.332	0.766	-0.118	-0.719	0.485
Partner effects						
PartnerT1 → PartnerT2	0.587*	0.318	0.858	0.693*	0.409	0.979
ActorT1 → PartnerT2	0.085	-0.246	0.416	0.076	-0.303	0.456
Collaborative planning → PartnerT2	0.543	-0.084	1.166	-0.120	-0.801	0.554
Collaborative planning+need supportive communication → PartnerT2	0.221	-0.431	0.872	-0.396	-1.079	0.284
Age	0.002	-0.035	0.039	-0.029	-0.070	0.012
SES	0.002	-0.003	0.007	0.000	-0.005	0.005
Number of children	-0.082	-0.637	0.476	-0.320	-0.910	0.272
	r			*r*		
ActorT1 ↔ PartnerT1	0.056	-0.233	0.335	0.055	-0.234	0.334
ActorT2 ↔ PartnerT2	0.078	-0.301	0.438	0.094	-0.335	0.494
Posterior predictive *p* value	0.352 [-24.797, 34.293]			0.290 [-22.926, 37.756]		

Note. *denotes a 95% CI excluding zero

Table S14

Confidence in Partner to Support

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.479*	0.200	0.749	0.613*	0.322	0.904
PartnerT1 → ActorT2	0.019	-0.307	0.349	-0.127	-0.487	0.234
Collaborative planning → ActorT2	0.258	-0.321	0.839	0.380	-0.225	0.981
Collaborative planning+need supportive communication → ActorT2	-0.246	-0.822	0.328	0.101	-0.503	0.702
Age	-0.022	-0.081	0.036	0.001	-0.058	0.060
SES	0.001	-0.004	0.005	-0.002	-0.007	0.002
Social support	0.175	-0.297	0.643	0.070	-0.425	0.569
Breastfeeding	-0.016	-0.468	0.433	-0.114	-0.585	0.356
Number of children	0.161	-0.379	0.714	0.271	-0.295	0.845
Partner effects						
PartnerT1 → PartnerT2	0.868*	0.681	1.054	0.745*	0.411	1.076
ActorT1 → PartnerT2	0.014	-0.143	0.170	0.217	-0.043	0.477
Collaborative planning → PartnerT2	-0.084	-0.415	0.248	-0.400	-0.941	0.145
Collaborative planning+need supportive communication → PartnerT2	-0.192	-0.522	0.141	-0.817*	-1.367	-0.267
Age	-0.004	-0.018	0.010	-0.006	-0.037	0.026
SES	0.000	-0.003	0.002	-0.002	-0.006	0.002
Number of children	-0.086	-0.371	0.200	-0.076	-0.557	0.401
	r			*r*		
ActorT1 ↔ PartnerT1	0.251	-0.036	0.500	0.251	-0.037	0.499
ActorT2 ↔ PartnerT2	0.340	-0.005	0.609	0.244	-0.126	0.550
Posterior predictive *p* value	0.238 [-18.836, 37.608]			0.557 [-32.255, 25.763]		

Note. *denotes a 95% CI excluding zero

Table S15

Confidence in Partner to Exercise

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.521*	0.204	0.835	0.526*	0.175	0.875
PartnerT1 → ActorT2	-0.239	-0.561	0.083	-0.057	-0.435	0.320
Collaborative planning → ActorT2	-0.136	-0.769	0.502	0.228	-0.509	0.967
Collaborative planning+need supportive communication → ActorT2	0.193	-0.461	0.848	0.335	-0.408	1.077
Age	0.052	-0.006	0.111	0.004	-0.063	0.069
SES	-0.002	-0.006	0.003	-0.002	-0.007	0.003
Social support	-0.017	-0.517	0.483	0.057	-0.529	0.645
Breastfeeding	0.005	-0.471	0.487	0.078	-0.485	0.638
Number of children	-0.363	-0.962	0.235	0.167	-0.519	0.862
Partner effects						
PartnerT1 → PartnerT2	0.601*	0.236	0.960	0.719*	0.378	1.061
ActorT1 → PartnerT2	-0.146	-0.470	0.180	-0.039	-0.344	0.264
Collaborative planning → PartnerT2	0.162	-0.523	0.842	-0.130	-0.773	0.519
Collaborative planning+need supportive communication → PartnerT2	-0.019	-0.729	0.692	-0.531	-1.190	0.136
Age	0.010	-0.026	0.046	-0.021	-0.055	0.014
SES	-0.003	-0.008	0.002	-0.004	-0.009	0.000
Number of children	0.135	-0.462	0.730	0.122	-0.461	0.701
	r			*r*		
ActorT1 ↔ PartnerT1	-0.108	-0.380	0.183	-0.107	-0.381	0.182
ActorT2 ↔ PartnerT2	0.364*	0.018	0.631	0.279	-0.084	0.576
Posterior predictive *p* value	0.580 [-31.914, 25.079]			0.513 [-30.697, 27.532]		

Note. *denotes a 95% CI excluding zero

Table S16

Relation-inferred Self-Efficacy

	Baseline-Post-intervention			Baseline-Follow-up		
		95% CI			95% CI	
	B	*Lower*	*Upper*	*B*	*Lower*	*Upper*
Actor effects						
ActorT1 → ActorT2	0.403*	0.094	0.711	0.597*	0.283	0.912
PartnerT1 → ActorT2	0.096	-0.212	0.408	0.088	-0.277	0.456
Collaborative planning → ActorT2	-0.183	-0.756	0.395	0.238	-0.373	0.846
Collaborative planning+need supportive communication → ActorT2	-0.137	-0.691	0.422	0.435	-0.153	1.024
Age	-0.004	-0.061	0.051	-0.012	-0.069	0.044
SES	-0.001	-0.006	0.003	0.000	-0.004	0.004
Social support	0.116	-0.333	0.565	-0.262	-0.759	0.239
Breastfeeding	0.136	-0.303	0.580	-0.136	-0.632	0.364
Number of children	0.120	-0.417	0.671	0.086	-0.483	0.651
Partner effects						
PartnerT1 → PartnerT2	0.522*	0.245	0.804	0.730*	0.376	1.081
ActorT1 → PartnerT2	0.123	-0.130	0.372	0.171	-0.138	0.483
Collaborative planning → PartnerT2	-0.273	-0.732	0.192	-0.177	-0.745	0.384
Collaborative planning+need supportive communication → PartnerT2	-0.036	-0.483	0.420	-0.335	-0.898	0.218
Age	-0.018	-0.045	0.009	-0.005	-0.039	0.029
SES	0.000	-0.003	0.003	-0.001	-0.005	0.003
Number of children	-0.240	-0.648	0.162	-0.250	-0.762	0.267
	r			*r*		
ActorT1 ↔ PartnerT1	0.048	-0.239	0.329	0.049	-0.240	0.328
ActorT2 ↔ PartnerT2	0.413*	0.039	0.682	-0.246	-0.570	0.154
Posterior predictive *p* value	0.405 [-26.381, 32.491]			0.624 [-34.590, 23.244]		

Note. *denotes a 95% CI excluding zero

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	Title
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	107
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	108
	2b	Specific objectives or hypotheses	113-114
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	115
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	114
Participants	4a	Eligibility criteria for participants	114
	4b	Settings and locations where the data were collected	115
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	116-117
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	114-115
	6b	Any changes to trial outcomes after the trial commenced, with reasons	n.a
Sample size	7a	How sample size was determined	120
	7b	When applicable, explanation of any interim analyses and stopping guidelines	n.a
Randomisation:			
Sequence	8a	Method used to generate the random allocation sequence	115

generation	8b	Type of randomisation; details of any restriction (such as blocking and block size)	115
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	115
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	115
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	115 and 117
	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	118-120
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	118-120
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	150
	13b	For each group, losses and exclusions after randomisation, together with reasons	150
Recruitment	14a	Dates defining the periods of recruitment and follow-up	118
	14b	Why the trial ended or was stopped	114 and 118
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	141
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	121
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)	121-123, 142-149, and 154-168
	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	121-123
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	126-129
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	126 and 129
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	123-126
Other information			
Registration	23	Registration number and name of trial registry	n.a
Protocol	24	Where the full trial protocol can be accessed, if available	n.a
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	n.a

*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

CHAPTER FOUR:

Is It Better Together? Experiences of Postpartum Mothers and a Significant Other in their Lives in a Dyadic Physical Activity Program

Carr, R.M., Quested, E., Thøgersen-Ntoumani, C., Prestwich, A., Gucciardi D.F., & Ntoumanis, N.

Abstract

Increased physical activity predicts postpartum weight loss. The PEEPS study (Chapter 3) was a 12-week dyadic intervention for postpartum parents and involved motivation and implementation intention planning to promote physical activity. We found a small positive effect on PA for partners in the collaborative planning + need supportive communication group and mothers in the collaborative planning group. Unexpectedly, postpartum mothers in the collaborative planning + need supportive communication group scored lower on autonomous motivation for exercise and their partners had lower scores on their confidence in their partner's support. Planning and need supportive communication strategies thus, had somewhat surprising effects in this population. However, the intervention results did not reveal the thought processes underlying these effects or how the intervention could be improved. Thus, a qualitative study exploring mothers and their partners' experiences and barriers to the intervention would be meaningful. The present study reports the findings from the process evaluation which explored mechanisms of impact, i.e., what was and was not implemented, and potential contextual factors impacting intervention effectiveness. Twenty-seven participants were interviewed (age range = 26 - 61 years old). Most participants (89%) were romantic couples. Semi-structured interviews explored the acceptability, engagement, barriers and facilitators, and perceived outcomes of the implementation. The analysis was guided by the MRC process evaluation framework (Moore et al., 2015), using thematic analysis (Braun & Clarke, 2006). Benefits of the program included providing accountability and increasing physical activity commitment. Contextual barriers (e.g., childcare commitments) and personal barriers (lack of motivation and the wrong study partner) were identified. Participants were motivated by exercising as a family, and from receiving practical support on motivating their partner. Among other techniques, participants used prompts (e.g., their spouse coming home from work), as a cue to start their plans. Participants used the plans to change the focus from their children to themselves. Mothers have limited time due to the obligations of childcare, housework or shopping (Brown, Brown, Miller, & Hansen, 2001): being provided a set exercise plan and practical support from the partner can overcome this barrier. Many logistic issues need to be considered to optimise behaviour change in future research (e.g., providing free childcare or conveniently located exercise classes).

Is it Better Together? Experiences of Postpartum Mothers and a Significant Other in their Lives in a Dyadic Physical Activity Program

Physical inactivity is associated with a range of chronic diseases, morbidity, early death, and a substantial economic burden (Ding et al., 2016). Yet nearly 1 in 3 18-64 year olds are insufficiently active (Department of Health, 2017). The onset of parenthood has been associated with declines in PA (Solomon-Moore et al., 2017). Australian adults with at least one child at home were 20% less likely to meet the minimum PA needed for health benefits than adults without children at home (Armstrong, Bauman, & Davies, 2000). Globally, being insufficiently active is a more prominent problem among women than men (World Health Organisation, 2018) and in the year after childbirth, many women over 25 find fulfilling the role of a mother to be a key barrier to taking part in PA (Cramp & Brawley, 2006). Pereira et al. (2007) examined self-reported leisure time PA in 1442 women before pregnancy, during the 2nd trimester, and at 6 months postpartum. The prevalence of physical inactivity (i.e, achieving less than 150 minutes of moderate PA per week) rose from 12.6% before pregnancy to 21.7% during the postpartum period. PA interventions are thus warranted for postpartum parents, and particularly for women. Major life changes (such as having a child) are often associated with a decline in PA but they can also provide a window of opportunity to change (Wood & Neal, 2016). The present study evaluates the implementation of an intervention designed to increase PA in postpartum mothers.

Changes in lifestyles and priorities may play a significant role in altered PA habits during early parenthood. For example, the major life transition of becoming a parent can lead mothers to reconstruct their lifestyle to incorporate caring for a new baby (Hamilton & White, 2010b) and thus, cues to old PA habits may not be present (Wood & Neal, 2016). Mothers often relinquish the opportunity for recreational PA by putting the families' needs first (Saligheh, McNamara, & Rooney, 2016; Walsh, Whittaker, Cronin, & Whithead, 2018) as the health of the newborn is paramount (Østbye et al., 2009). Lack of time, inconvenient locations and high cost also stop mothers enrolling in postnatal PA classes (Saligheh et al., 2016). A free, home-based PA intervention could overcome barriers caused by inconvenient locations, restricted time and high costs associated with paying for PA activities. However, the social support that is available in group-based exercise is an important facilitator to sustaining PA among new mothers (Batey & Owton, 2014) and is usually missing from home-based interventions, posing a barrier to engaging in home-based PA.

Research has highlighted the perceived need for an ally to support new mothers' efforts to engage in PA. For example, women are more influenced by affective support from close friends/ family members than men (Oliveira et al., 2014). Almost every mother in Saligheh et al.'s (2016) interview study stated that having an "extra hand" for support would have facilitated their engagement in exercise. Dyadic (pair-based) interventions offer a solution by encouraging individuals to be active with the supportive involvement of a partner or friend. In a recent meta-analysis, dyadic interventions outperformed individual interventions as a means to promote PA (Carr et al., 2019).

In addition to the effects of social support, there are a number of ways dyadic partnerships can facilitate PA. One way is via the co-creation of PA plans. When people make plans to be physically active with a significant other they have greater PA levels compared to planning individually or not planning at all (Prestwich et al., 2012). Collaborative planning involves planning with a partner to do a future behaviour *together* (Prestwich et al., 2005): this was the first study to examine the use of this strategy to increase the PA of mothers. Another important determinant of initiating and sustaining engagement in PA is the quality of motivation underpinning PA behaviours. According to SDT theory (Deci & Ryan, 1985, 2000) an individual's motivation to be active will be more self-determined if significant others act and communicate in ways that support the target individual's innate psychological needs. Autonomy supportive behaviours include creating opportunities for choice, and inviting input into decisions making, and promoting feelings of volitional engagement and intrinsic interest in the activity. Relatedness supportive behaviours include demonstrating respect, care, and support of the significant other, and acknowledging the partner's feelings, desires and frame of reference. Competence is supported when efforts and achievements are recognised and celebrated and when there is encouragement for each other's initiative, and capabilities to carry out self-chosen behaviours (Ryan & Deci, 2017). A plethora of research has indicated that when basic needs are supported, people are more likely to sustain engagement in PA or exercise (Edmunds, Ntoumanis, & Duda, 2007; Silva et al., 2010). To promote PA among inactive mothers via a dyadic intervention, it may therefore be beneficial to train partners in how to support each other's basic psychological needs in relation to PA behaviours.

The Postnatal Exercise Partner-based project (PEEPS) was a 12-week randomised controlled trial that aimed to determine the efficacy of a dyadic PA intervention based on SDT (Deci & Ryan, 1985, 2000) and use of collaborative implementation intentions (Prestwich et al., 2012) (presented in Chapter 3). Participants were mothers of a child aged

between 3 and 24 months and their study partner and dyads were randomised into one of 3 conditions. All conditions (including the control) attended a workshop (delivered by the first author) in which they received recommendations for PA, discussed barriers to being physically active, and set a PA goal. In the collaborative planning condition participants were also taught how to construct plans to exercise together (e.g., "if it's situation X then we will do Y") or to provide practical support (e.g., "if it's situation X then I will do Y and my study partner will do Z"). In the collaborative planning + need supportive communication condition, in addition to the aforementioned training, participants were taught how to support each other's basic needs for autonomy, competence and relatedness. Please refer to Chapter 3 for a complete description of the interventions and results. A small positive effect on total PA at 3-month follow-up was found for postpartum mothers in the planning group and for partners in the motivation + planning group. Partners in the motivation + planning group were 3.68 times more likely to engage in some vigorous PA at the follow-up as opposed to no vigorous PA, when compared to the control group. At the follow-up, unexpectedly, postpartum mothers in the motivation group scored lower on autonomous motivation for exercise and their partners has lower scores on their confidence in their partner's ability to support them, compared to the control group. Collectively, these results indicate that teaching mothers and their partner/friend how to plan and how to use motivationally adaptive communication strategies had somewhat limited and some unexpected effects in terms of increasing PA and motivation in this population. However, the trial results did not reveal processes explaining these effects, how the trial was implemented, nor how the intervention could be improved for the future (Moore et al., 2015). Thus, a qualitative study exploring mothers and their partners' experiences and barriers to the intervention would be meaningful.

Undertaking a process evaluation is important to understand the degree to which the intervention was implemented as intended and to reveal which intervention components did and did not have the intended effects, and why (Oakley, Strange, Bonell, Allen, & Stephenson, 2006). The key functions of a process evaluation, according to the MRC guidelines (Moore et al., 2015), are to describe the intervention and its assumptions, to assess what is delivered and how this was achieved, to assess how participants interacted with the intervention and any unexpected consequences, and to assess outcomes of the intervention. To inform practice and policy, we need an understanding of how the intervention works and the causal assumptions underpinning it (Craig et al., 2008). To this end, and guided by the MRC process evaluation framework (Moore et al., 2015), we aimed to explore 1) the acceptability of the 2 intervention conditions (i.e., planning, and

motivation + planning), (2) barriers and facilitators to intervention implementation, (3) how participants engaged with, and implemented, the intervention, and (4) perceived changes in PA from engaging in the intervention.

Methods

Main Study Procedure

This study was approved by the ethics board at Curtin University, Western Australia. For full details of the RCT see Carr et al, (in preparation). Participants were recruited from family and parenting centres in Western Australia and via social media advertisements (e.g., in parenting Facebook groups). Participants were provided with an information sheet and a link to an online consent form and screening survey. Eligible participants included mothers with a child aged between three and twenty-four months who self-selected a study partner (e.g., friend, romantic partner, family member) to invite to also take part. Both had to be over the age of 18 years, and somewhat active or not active (i.e., less than 24 units on the LSI index of an adapted version of Godin's (2011) PA Questionnaire). They were encouraged to seek their doctor's approval if any medical conditions were identified by the PA Readiness Questionnaire (Canadian Society for Exercise Physiology, 2002). Dyads were then randomised to one of three conditions, the full intervention (i.e., collaborative planning + need supportive communication; *n*= 18), collaborative planning only (*n*= 22) or the minimal treatment control (*n*= 19).

Participants completed self-reported surveys and wore Geneactiv accelerometers for one week to track their PA at baseline (week 0), week 4 of the program (first follow up; immediately post-intervention) and week 12 (second and final follow-up). Immediately after the baseline assessments, participants in all conditions received a 30-40-minute face-to-face (in person or via Skype) workshop or a video recording of the relevant workshop, delivered by the lead author. Across all conditions 18 participants attended face-to-face sessions and 10 participants received the workshop via a Skype video call. 18 participants participated in workshops in groups of 4-6 participants, while 10 workshops were pair-based. 73% of the participants could not attend in person or by Skype and so received a recording of the relevant workshop (*n*= 74).

The Intervention Conditions

In all conditions, dyads were recommended to try to achieve the Australian PA guidelines in an activity of their choice (Department of Health, 2019). In the control arm workshop, participants discussed with their partner barriers and facilitators to exercise, opportunities for PA in their local area and set a basic goal to be more active. In the

collaborative planning condition the dyads received additional training in how to form collaborative implementation intentions. They were encouraged to make plans to exercise together (e.g., if it's situation X [the time/event], then WE will do Y [the activity]), and to identify and plan ways they could enable their partner to realise their exercise intentions if exercising separately for example, by looking after the children or cooking dinner (if it's situation X then I will do Y and my study partner will do Z). In the collaborative planning + need supportive communication condition, dyads also received training in how to support each other's motivation to be active using need supportive communication based on principles of SDT (Deci & Ryan, 1985, 2000). See (Carr et al., in preparation) for further details of the intervention conditions.

Participants in all groups were told that the researcher was available for contact, to discuss the intervention materials and for queries if needed. A website was made available which included workshop resources and the PA guidelines (all groups), instructions on planning (collaborative planning condition; collaborative planning + need supportive communication) and fictitious case scenarios of a couple experiencing difficulties exercising and prompts to identify need supportive ways to interact with their partner in these scenarios (collaborative planning + need supportive communication condition). In addition, private Facebook groups were created with security settings so that participants could only access content specific to their intervention allocation. The control condition were advised to use the website for sharing exercise tips or websites, the planning condition were encouraged to use the group to share their success and failures in pursuing their plans, and the participants in the motivation + planning were recommended to share tips on need supportive communication.

Process Evaluation Participants and Procedure

Fifty-six participants from the planning or collaborative planning + need supportive communication interventions who had also completed the final follow-up were invited to be interviewed. All willing dyads were interviewed. Twenty-seven participants from 19 dyads (a participation rate of 48%) agreed to be interviewed; 11 dyads from the collaborative planning condition and 8 dyads from the collaborative planning + need supportive communication. Participants could raise any questions or concerns about being interviewed, were provided with an information sheet and asked to complete a consent form prior to participating in the interviews. Participants could complete the interview either with their study partner or independently. Twenty-four interviews were conducted on a one-to-one basis. The postpartum mother was unavailable to be interviewed in one dyad. Two participants were

from friend dyads and one dyad consisted of a mother and daughter. The remaining 24 participants were romantic couples. The participants' ages ranged from 26 to 61 years old.

The semi-structured interviews included 15 open-ended questions based around topics of (1) motivation to join the study, (2) the resources received, (3) use of the implementation intention plans, (4) their experiences of motivating each other, and (5) their perceived effectiveness of the program. The participants from the collaborative planning + need supportive communication were also asked specifically how they used the motivation strategies they had discussed in their workshop. Prompts were used for clarification and elaboration. All but 1 interview took place by phone. Interviews lasted between 20 and 75 minutes.

Analysis

All interviews were audio recorded and transcribed verbatim by a 3rd party company, and then coded using Version 11 of NVivo Qualitative Data Analysis Software (2015). The analysis was guided by the MRC process evaluation framework (Moore et al., 2015), with a view to understanding if and how the intervention worked, i.e., what was and was not implemented, and how, potential causal mechanisms and how contextual factors may have impacted intervention effectiveness. Data were analysed using thematic analysis (Braun, Clarke, & Weate, 2016). We carried out the analysis in six steps (Braun & Clarke, 2006). First, the lead author familiarised themselves with the data and then assigned raw data codes to relevant sections of the transcript. We utilized both inductive and deductive approaches to the analyses using established theory to explore principles from SDT (Deci & Ryan, 1985, 2000) and collaborative implementation intentions principles (Prestwich et al., 2005). For instance, in a deductive approach, the first author looked for text which related to specific theoretical constructs that underpinned the intervention design. For example, we coded different types of motivation e.g., introjected (guilt, shame) or intrinsic motivation (e.g., enjoyment). The researcher also explored whether participants felt PA had become more habitual or structured from following the PA plan. In an inductive approach, the author read the transcripts in detail to find new ideas or constructs. For example, we summarised sections of text to provide a description of what the participants were expressing, by paraphrasing (e.g., "[mother] felt the researcher needed to check in or follow-up with them" or "[mother indicated] the intervention does not work for their situation at home"). We then categorised the codes into themes both at the latent and semantic level. Latent themes refer to the underlying meaning interpreted from what participants said e.g. evidence of having a superficial understanding of motivation; semantic themes refer to issues explicitly identified

by the participant, e.g. work or the weather as barriers to exercise. Transcripts were examined deductively for references to need support and to external, introjected, identified, integrated regulations underlying the reasons for being physically active (Deci & Ryan, 1985, 2000). Transcript were examined inductively by searching for data-driven themes that did not fit established theory. The first and second author discussed and reviewed the identified themes to reach a consensus, checking the themes against the transcripts for accuracy. These two authors collaboratively defined and named the themes. All disagreements were discussed and resolved at each stage. The final stage involved producing this report.

Data Rigour

At the end of the interviews, the researcher summarised what the participants liked and disliked and asked if there was anything more to add. This was to help ensure a common understanding and to prompt participants if they had forgotten anything. Saturation of the topics seemed to be achieved after the interviews were finished. To avoid the lead author's personal view from affecting the results, two authors independently coded one transcript and discussed the coding to reach a consensus. The first author coded all the remaining transcripts, but the second author reviewed and discussed the coding, themes and interpretation of the data until a consensus was reached. This process involved the creation of a thematic map which was presented to the second author who asked them to justify the rigour of and rationale for the themes.

Results

Overview of Results

Participants are referred to by a pseudonym to protect their identity. The participants' intervention condition is presented in brackets after each quote. Themes are organised within four broad headings that align with the four aims of this paper and the key principles from the MRC guidance (Moore et al., 2015). See Table 1 for a complete list of themes, sub-themes and example quotes for each theme. An overview of the prominent themes identified in the analysis are presented below.

Intervention acceptability

Acceptability refers to the extent to which participants consider the intervention to be appropriate, based on their emotional and cognitive responses to it (for example, the burden placed on them, their feelings and attitudes, and/or self-efficacy to carry out the strategies) (see Sekhon, Cartwright, & Francis, 2017). Three themes were identified that provided insight into the acceptability of the intervention that reflect some variability in how participants responded to intervention. Many of the participants indicated that they did not

use the intervention materials (e.g., planning sheets, motivation sheets, website) to generate PA plans or to motivate each other.

Four themes (need for exercise prescription from the researcher, the intervention felt tedious, sparks an interest or awareness of PA, dislike of online features) were identified to help explain this lack of engagement with these intervention materials. Please refer to table 1 for illustrative quotes of all the themes.

Need for exercise prescription. Participants in both conditions described that they expected to exercise in a face-to-face session or wanted the researcher to be more directive, by saying things like, "*here's half a dozen examples of, of um, of activities or 'this is what you guys can do'"* (Collaborative planning, Wesley, 46 years, first time father). They felt that the researcher needed to provide more direction, more prompts and set their goals for them. *"Um, obviously yes, you [the researcher] were there for the support and the feedback, but for me it helps if someone goes, 'okay, every whatever, every day or every second day, you are to do this for this long and you will see this result in X amount of days, weeks'."* (Collaborative planning, Caroline, 31 years, first time mother). Although SDT predicts that individuals should thrive in environments that promote choice and personal decision making, these quotes illustrate that some individuals would have preferred a higher level of structure than was offered in the PEEPS intervention.

The intervention felt tedious. Some participants reflected that they found the intervention to be somewhat laborious. The planning task was perceived as repetitive and tedious. "*No, I would say for the planning stage, I know that's what the program is about, but it did get a little bit tedious. ...It was a bit of, a bit, um, there was a bit of repetition in it."* (Collaborative planning, Brady, 33 years, first time father). Participants in the collaborative planning + need supportive communication condition remarked that their workshop felt too long *"It would work very well for us, probably better ... not- not saying very well, but probably better ... if, um, if it was a bit shorter and just give us a gist of what they expected from us-*" (Collaborative planning + need supportive communication, Darla, 41 years, mother of 2). One mother emphasised how the intervention would benefit from increased focus on key expectations rather than covering a range of topics. Parents also alluded to how the workshop could be divided into smaller modules to be completed over a few days rather than all the content at once.

Sparks an interest or awareness of PA. Participants explained that the program got them thinking about PA and exploring different ways to become more active. *"I have fitness goals to achieve now so, I'm really pumped…So this is the best kick up the bum that I ever*

could've had. It just, it literally gave us a reason to start everything" (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3)... *"I think, uh the pro- the program, was so good ... that it was, it was designed to um push us in a direction that works for us and we made sure that we found something that fitted our needs"* (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3).

Barriers to intervention implementation

Some participants felt that despite wanting to engage with the intervention materials and increase their levels of PA, several barriers prevented this (see Figure 1, supplementary materials 1). Five themes were identified that reflected barriers to intervention implementation: lack of motivation, work, study or chores, medical conditions, tiredness, finances (please refer to table 1 for an exemplar quote from each theme).

Lack of motivation. Several participants across both conditions described lacking motivation to exercise and attributed this as their reason to not engage with the intervention materials or put their plans into action. Some participants mentioned that their partner would use the motivational strategies, but they would not find them effective as they perceived themselves to be hard to motivate: *"I'm very hard to motivate. I've really, really struggled with everything. So, um, it, you know? I think, I think he would take a lot of the, um, uh, um, a lot of the sort of suggestions on that handout. But, um, yeah. I'm just a hard nut to crack I guess."* (Collaborative planning + need supportive communication, Grace, 34 years, first time mother). For some participants, the motivation issue was attributed to personality characteristics of both members of the dyad, such as being "lazy" or not the exercise "type". For example, Brady stated, *"We're both the same type of people. We're, not, not big on exercise, so it's hard to motivate ourselves and each other"* (Collaborative planning, Brady, 33 years, first time father). In this respect, the participants felt that lacking motivation to engage in the program was a personality-based issue.

Appropriateness of study partner was a sub-theme identified which further explained 'lack of motivation'. Some participants felt, in hindsight, that they would have engaged more with the joint plans or motivation strategies if they had chosen a different study partner. Reasons for this included the partner (often the father) not being engaged with the study, or because their living circumstances prevented them from exercising together, or because they had a closer relationship with someone else.

"I think if we could have exercised together, it would definitely have been more helpful, because we would have made a commitment that we're doing something on whatever day and, you know, you tend to do it when someone else is there, so you can't get out of it. So

if we're doing together, I definitely think it would have- would have motivated us to do more." (Collaborative planning, Luna, 40 years, first time mother). Notably, participants felt if their study partner had been someone in a similar situation to them this would have facilitated exercising together, *"Interviewer: Can you just clarify again ... why you wanted your sister? Luna: I guess cos we've got a, you know, a closer relationship. And, um, we could exercise together. And, um ... you know, we've both got kids at the same age, so ... that would've made it easier."* (Collaborative planning, Luna, 40 years, first time mother). This quote suggests that it is not just social support from another person that facilitates engagement in PA., In the case of mothers, commonalities such as similar family circumstances can set the stage for plans to be more easily implemented.

Work, study or chores. Work commitments or chores were a prompt to be active for some, and a barrier to PA for others. For example, Ivy said *"he's been working about 80 hours a week. So, you know, by the time he gets home at 10:00 pm, 11:00 pm, it's too late"* (Collaborative planning, Ivy, 29 years, mother of 2). However, some dyads used their partner returning home from work as a cue to implement their plan.
"... going for a walk when I got home from work, on the days that I didn't work late or anything like that. Um, just, yeah, I get home and we'd, we'd take [our daughter] in the pram and go for a walk for half an hour or 45 minutes, whatever it might be, or even if it was a bit later, we could go for about ten minutes." (Collaborative planning, Brady, 33 years, first time father).

Participants also identified housework or chores as a way to fulfil their PA targets, which meant that even when not sticking to the plans, they managed to engage in PA. These kinds of home activities were perceived to be more convenient. For example, Miles discussed how his preferred exercise plan was to go kayaking [inconvenient] but instead his usual exercise consisted of lawn mowing [more convenient] *"Well the usual things, as far as my exercise, so you know pushing the lawn mower around. I take pride in my lawn- uh you know, through the summer, I manage to do that every weekend*." (Collaborative planning, Miles, 40 years, father of 2)

Facilitators to intervention implementation

Five broad themes were identified that describe facilitators to engagement with the intervention: weight loss, commitment to the dyad, childcare provision, personal motivation, and visual materials (Figure 2, supplementary materials 1).

Weight loss. Even though the program focused on promoting PA, many participants from both groups were motivated by weight loss. Participants perceived fitness changes as

harder to track and less personally satisfying than monitoring weight loss. Participants discussed how the goal of weight loss kept them engaged with the intervention, and perhaps less likely to drop out of the study: *"I think like in my mind- I really, really wanted to lose the pre-pregnancy weight. Like I really ... And that's why I stayed in it. Because even though I found it difficult, I still had in my mind that, you know, I wasn't happy with the fact that I was still wearing maternity clothes."* (Collaborative planning + need supportive communication, Janet, 37 years, mother of 2).

Commitment to the dyad. Some participants in the collaborative planning condition discussed how they would not exercise on their own and that they felt more committed and more confident from exercising together via a structured plan as a couple: *"when you're both committed to a certain time or activity to do it's certainly a bit more motivating"* (Collaborative planning, Stephen, 40 years, father of 2). They also discussed wanting to find activities they can do together as a couple rather than always focusing on the baby: "*we were really conscious of trying to find ways that we could do things together as a couple… Um, rather than just, you know, always spend time with the baby, and about the baby, and stuff like that."* (Collaborative planning + need supportive communication, Katarina, 40 years, first time mother).

Motivated by exercising as a family. Parents in both conditions often felt motivated to exercise because they could involve the whole family, which could be interpreted as reflective of identified reasons to be active: *"it's always good to go for a walk as a family and have some time together without- Not sitting around the dinner table or anything like that"* (Collaborative planning, Brady, 33 years, first time father). One mother described being motivated by her daughter's enjoyment of being outdoors *"Now, um, that she's older. She's nearly two, um, and she likes being outside, so she encourages us to go for a walk…Because if you don't, then she chucks a tantrum."* (Collaborative planning, Caroline, 31 years, first time mother).

Sense of connectedness. In both conditions participants described using the planning task to schedule walking together as they enjoyed the conversations with their study partner when walking and this created an opportunity to experience feelings of relatedness: *"Relatedness, definitely, when we go for those walks each week, we have really good conversations and that's just really lovely. So, that's improved"* (Collaborative planning + need supportive communication, Katarina, 40 years, first time mother). Participants alluded to how the program helped them understand each other better which contributed to feelings of connection "*I would say more connected, because like I said, we were able to figure out what*

the other person's priorities are, when it comes to the time they need, which helped us understand each other a little bit better." (Collaborative planning, Nate, 35 years, first time father). These quotes also illustrate that feeling close to the study partner is important for PA facilitation.

Childcare provision. Some participants tackled their childcare barriers by using the plans to take it in turns to look after the children, so they each could exercise or have personal time. *"Where we're making a plan of, um, like taking turns with exercising and taking turns with who's looking after the baby… Um, so I think that was helpful."* (Collaborative planning + need supportive communication, Faith, 26 years, first time mother). However, some participants in the collaborative planning + need supportive communication condition described this type of practical support as more useful than (what they perceived to be) motivational support.

"Um, just ... even just things like, um, you know, getting the girls breakfast so I can get ready to go ... or um, you know, just things like that is a, is a big help, which he, he does all time. We're definitely 50/50, so that's no problems, that ... but that's something that I would appreciate more like than, "Come on, you got to go to the gym" or *"Come on, you know, get ready or don't eat that or don't", you know. So he, yeah. He knows the right things to do."* (Collaborative planning + need supportive communication, Angel, 35 years, mother of 2).

However, others found the demands of childcare meant being active was not possible for them. They alluded to feeling like they were 'putting out fires' or juggling too many demands:

"Um, so one aspect um whether the baby slept well the night before, um and whether or not I have a kid home during the day, 'cause I have one at school full-time and one at school in kindy, so she goes two and a half days a week. And then I have the baby at home, so making a plan for each set day, in my head I had said, "Well no, I won't be able to do this because um there's too many variables." (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3).

How participants implemented the motivational strategies or planning activities. Six themes were identified and are presented in Table 1 and Figure 3 (supplementary materials 1).

Motivation Components. ***Emphasising intrinsic reasons to exercise.*** Participants attempted to promote feelings of autonomy in their partner by highlighting

values, intrinsic goals for exercise, or positive feelings they would experience from exercise. For example, some reminded their study partner why they had wanted to be more active and highlighted the benefits they would experience from exercise. *"like reminding him, "Oh you'll feel better after you exercise." And, um, um, talking about how we, we were wanting to exercise more 'cause ... and why we both wanted to do that and stuff like that."* (Collaborative planning + need supportive communication, Faith, 26 years, first time mother*).* One mother of three described how having a supportive partner led her to develop autonomous reasons to be active, which she found helped her to push herself.

"Um, to check in. Like, we both do that for each other, but we don't, we don't really see it as a job. We just kind of do it, and if she wasn't there, I'd probably struggle to intrinsically motivate myself. I could probably put, have um extrinsic stuff to motivate me-... but, it's the stuff that you do inside, the things, the drive that you've got inside of yourself that pushes you that little bit further." (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3)

Ella also discussed how she tried to focus on improvements in fitness not weight loss:

"So we're trying not to focus on um, centimetres lost or weight loss-... we, we do a fitness test at the beginning of our challenges. And we do a fitness test at the end of our challenges. And that's to see how much you've improved... [my partner] *and I had um, a sock bit. Um, so that's a pair of exercise socks. Nothing too exciting…* [for] *who, who got the best improvement on their fitness test. Not who got a higher score on anything-... but, the best improvement on it. Um, and it's, it's based, it's based on the fact that you get to wear the socks-"* (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3).

In contrast, Janet for example, discusses how her partner would motivate her by saying *"Now you are losing weight. You look good."* (Collaborative planning + need supportive communication, Janet, 37 years, mother of 2). Katarina discusses how she struggled to find intrinsic ways to motivate her partner, as he was more concerned with weight loss: *"He, I think, most of the reasons he exercises is because he, you know, thinks he needs to lose a bit of weight or stay in shape, or his jeans don't fit. It's not because he likes exercising, so ... It was hard for me to find an intrinsic way to motivate him, so that's* [why I'm] *not sure if it worked."* (Collaborative planning + need supportive communication, Katarina, 40 years, first time mother).

This is potentially problematic, as Ella alluded to how focusing on other factors (e.g. improving fitness) rather than weight loss helps with PA maintenance *"I think when we look*

at those sorts of things, And that's how she would pull me out of that, so I didn't sit there going, "Well, there's no point in exercising because I'm not losing weight." (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3).

Use of a questioning style. Participants in both conditions described that their study partner would ask prompting questions to 'check in' on how they were going with their PA plans (a strategy with potential to support feelings of autonomy and relatedness) and participants felt this helped them to feel valued. *"Um, it- it made me feel validated, I guess…Because it's- it's always really hard because obviously he's working long hours and then it's all- all about the kids, mainly. So it was nice, it was nice that he'd ask you know, how I was going and if I managed to do what I wanted to do, which was go for a walk… So yeah, it was, it- it, yeah. It- it was nice."* (Collaborative planning, Ivy, 29 years, mother of 2). Some participants said that their partner stopped 'checking in' with them once they realised they were carrying out their plans.

"He- he did every now and then, especially in the beginning. He would ask, you know, "Have you been for a walk?"...How's your walking going? Were the kids alright? You know, were you, are you managing to- to do it with the kids? But after a while, I think he got the idea going, "Yeah, she's, you know, she's- she's fine doing it-"... "Whether I ask or not." But he just sort of stopped asking." (Collaborative planning, Ivy, 29 years, mother of 2). However, Ivy still managed to carry out her plans without this motivational support from her partner as she was self-driven. This suggests that partner support may have been important in helping her to motivate her to initiate regular PA and once the behaviour was initiated she was autonomously motivated to sustain it. *"Um, it was because I was actually doing, you know, I followed the plan and exercising a lot-… I wasn't actually motivated a lot because I was quite motivated within myself to do it."* (Collaborative planning, Ivy, 29 years, mother of 2).

Superficial understanding of motivation. Some participants had the view that motivating their partner meant cheering them on, however, from an SDT perspective, this type of motivational support may lack need supportive characteristics and could in fact be described as 'need indifferent' (Quested, Ntoumanis, Stenling, Thogersen-Ntoumani, & Hancox, 2018). *"I'm not really one of these like, "Come on, keep going", you know, I don't respond to that at all. And [my partner] knows that, so probably the less that he says is better."* (Collaborative planning + need supportive communication, Angel, 35 years, mother of 2). Negative connotations associated with spouses "nagging" their partners, may also help explain why some participants felt reluctant to implement the motivational strategies. When

asked what they did to motivate each other, one mother replied *"Uh, gosh. Look, not much. I find that really hard because I feel sometimes that even if I'm connecting into those three Cs, it still feels like nagging."* (Collaborative planning + need supportive communication, Katarina, 40 years, first time mother).

Some participants saw value in the intervention but believed they were already active, self-driven or naturally supportive of their partner, and therefore did not need to implement the motivational or planning behaviours that the intervention was intended to encourage. *"I think I'm quite a self-driven person. Um, so whether he motivated me or not (laughs) probably-... doesn't, um, change what I'm gonna do much. (laughs)."* (Collaborative planning + need supportive communication, Darla, 41 years, mother of 2). Some participants felt they already knew the information.

Use of controlling strategies. Participants in both conditions described using motivational strategies with their partner that, from the perspective of SDT, would be considered controlling. For example, Ella stated: *"I will, uh usually find or source, um, a workout that I've got ready to go, just in case I can't get to the gym. And I will make [my study partner] um, do that as well, whether or not she likes it (laughs)."* (Collaborative planning + need supportive communication Ella, 34 years, mother of 3). However, participants across both conditions also recognised the inappropriateness of using controlling strategies.: *"Like, you- you work for somebody, you go- and they've got a job- You're like, "Come on, mate. You do your job. Hurry up and do your job." Versus you can't say that to your wife."* (Collaborative planning + need supportive communication, Oakley, 33 years, father of 2). This quote illustrates that participants avoided controlling strategies because they considered them inappropriate to use with their partner. This perspective seemed particularly evident in romantic dyads.

Felt exercise was imposed on them. Although the program emphasised choosing their own activities, in both conditions, some participants felt that PA was imposed on them or their partner *"He felt like he had a bit too much on his plate perhaps and felt like this exercise was, um, being imposed upon him rather than something that he was choosing to do."* (Collaborative planning + need supportive communication, Katarina, 40 years, first time mother). However, some participants agreed to take part in the study primarily to please their study partner *"[I signed up] mainly because my daughter wanted to and she told me to do it. … I did it for her sake. So on my end I didn't want to do it myself, I did it for her sake"* (Collaborative planning, Rose, 61 years, Grandmother). In the case of these participants from

both conditions it seemed that motivation to be active did not become autonomous during the program.

Commitment and accountability. Some participants felt that the planning activities were useful as they felt more accountable and motivated. For example Ivy states *"I think it's just the fact that it was written down and that's because it- it was sort of a motivation-"* (Collaborative planning, Ivy, 29 years, mother of 2). The program provided a reason to *"commit to something"* (Collaborative planning + need supportive communication, Ella), and participants reported thinking *"well we've got to do this"* which they felt increased their use of the plans (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3). However, this wording also reflects a feeling of obligation, which suggests planning could have led to introjected motivation for PA. Introjected regulation is associated with negative emotional contingencies and is less sustainable, which could account for reduced engagement among some participants. Some participant felt that they would have benefitted from meeting other participants face-to-face or being part of a larger group than just themselves and their study partner. *"For me, I think what it would have helped me, um, engage with it a little bit more would have been that pressure of knowing that I, at some point I actually have to see people and have to talk about it."* (Collaborative planning + need supportive communication, Grace, 34 years, first time mother). It is noteworthy that this participant also alludes to a perceived preference for 'pressure' which would likely lead to more extrinsic than intrinsic motivation to be active.

Planning components. Participants in both conditions found it difficult to implement their plans. Two themes were identified that relate to implementation of the planning aspect of the intervention (flexibility with plans and how it is easy to set plans but hard to carry them out).

Flexibility with plans. Participants highlighted that flexibility to adapt plans at short notice was important, if activity goals were to be achieved. Some participants described strategies they implemented to pre-empt and address disruption to plans: *"And I usually have a plan B and a plan C and a plan D. In case things go wrong (laughs). And that's my personality type, so no. That's why I didn't have a problem with it at all"* (Collaborative planning, Rose, 61 years, Grandmother). However, not all participants were successful in adjusting plans: "we would have to make a new plan, but we haven't done that"

(Collaborative planning + need supportive communication, Faith, 26 years, first time mother).

Impact of the interventions

Four broad themes were identified that reflected the participants' perceptions of the impact of the intervention (new ways of thinking, PA is now more natural, the program increased their PA, and integrated motivation) (Figure 4, supplementary materials 1). Please refer to table 1 for more descriptions. Many participants in the two intervention conditions alluded to changes in their thoughts and attitudes to PA, as a result of participating in the program.

New ways of thinking. Some participants encountered unexpected new ways of thinking about how PA can successfully be accrued, for example, realising that exercise can involve children, *"[I was] worried that if I wanted to go for a walk every day or every other day, that the kids are gonna- gonna kick up a fight because they have- To sit in the pram for 30 minutes. And it turned out to be completely in my head because the kids were fine-"* (Collaborative planning, Ivy, 29 years, mother of 2). Participants also referred to changes in their beliefs related to what they could achieve. For some, increasing perceived competence through peer support was a key component to these new realizations "*... everything was done together and we, if we tried and we were scared, we did it together and we realized that we could do it."* (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3)

PA is now more natural. Some participants felt that PA was more natural as a result of taking part in the intervention. *"Uh, yeah, it, to start off it was, um, you knew that there was, we were making an effort to make sure that we-... we did it, but now it just, it seems natural."* (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3)**.** This quote illustrates that PA has become more automatic and habitual, requiring less effort than it did previously. Poppy's comments reflect of an integrated style of motivation and thought process "*Well, I suppose while we're following the plan, we were sort of like, "This is just what we do."... But um ... Yeah. We, I, I don't know. We didn't really say anything to each other to motivate each other"* (Collaborative planning, Poppy, 30 years, first time mother).

Program increased their PA. Participants alluded to how the program increased their PA for example, as a result of signing up to PA classes or joining challenges:

"So we were aiming for at least three days a week. that, as of well, today, um I went twice to the gym today. And last week I think I did six sessions. Including a gymnastics class.

So we, we've gone from thinking maybe we will just organize ourselves… Um getting on board, to eight week, eight week challenge program that was gonna help us, um, run alongside in the program, but also give us more structure and set classes to go to. As opposed to anything else. Um, to now really loving what we're doing and getting really upset if we have to miss a day because our kids are sick." (Collaborative planning + need supportive communication, Ella, 34 years, mother of 3).

Others noted that although the changes in PA did not yet reach recommended levels for health, they were still more active now than they were before the intervention. For example, Poppy discusses how her PA had increased but not to a large extent as she was very inactive before the study, "*Maybe not like hugely, but you know, we went from doing nothing. Um, so we're probably won't have like ... We probably won't meet the guidelines straightaway. But the fact that we started with nothing, um, I think it's ... we'll definitely be a lot more active and I think we'll probably even be closer to meeting the, the um, healthy guidelines than we were before we started the study."* (Collaborative planning, Poppy, 30 years, first time mother)

Discussion

As a key life transition (Hamilton & White, 2010b), the postpartum period provides an opportunity for change and is a prime opportunity for intervention as people may have increased perceptions of vulnerability to health risks (Østbye et al., 2008) and cues to old PA habits may no longer be present (Wood & Neal, 2016). Previous studies have identified family or partner support as a key facilitator of PA in the postpartum period and beyond, for example, among working mothers (Albright, Maddock, & Nigg, 2005; Brown et al., 2001; Miller et al., 2002). The recent meta-analysis by Carr et al. (2019) highlighted the promise of dyadic interventions to promote PA. Several studies in this meta-analysis involved parent-child dyads (often the mother), however, the focus was often on the child's PA levels, not the mother's; to our knowledge, this trial was the first ever dyadic physical activity intervention aimed at postpartum parent couples.

The intervention conditions promoted the use of planning strategies (Prestwich et al., 2012) and planning plus motivationally adaptive communication strategies (Hancox, Ntoumanis, Thøgersen-Ntoumani, & Quested, 2015). Dyads were randomised to one of three conditions: collaborative planning + need supportive communication training, planning only or the minimal treatment control. In the present study, we explored parents' experiences of participating in the intervention. We used the MRC framework (Moore et al., 2015) as a guide to explore the acceptability of the interventions (i.e., collaborative planning, and collaborative planning + need supportive communication), barriers and facilitators to intervention implementation, how participants engaged with, and implemented, the intervention, and perceived changes in behaviour as a result of engaging in the intervention.

Acceptability

Results from the participant interviews indicated that both dyadic interventions were acceptable to some participants, particularly among those who self-reported increased PA. For example, these participants stated that the planning task was simple and straightforward, that the materials included good ideas, and that the recommendations or motivational materials were helpful. However, there were several issues regarding engagement with both the intervention and the study overall. In terms of participation in the research activities, some participants were non-compliant in wearing the accelerometers or completing the questionnaires. Some participants found the intervention workshops were too long or that the planning materials were tedious and repetitive. Others stated that they did not really engage

with the online components. The interviews did not reveal notable differences in engagement and implementation between the two treatment conditions. This lack of notable difference could explain why in the main trial paper (Carr et al., in preparation), there were benefits for participants in both conditions - the mothers increased their total PA in the collaborative planning condition, while partners increased their vigorous PA in the collaborative planning + need supportive communication condition (i.e., people perceived the same benefits and drawbacks in both conditions). In the collaborative planning + need supportive communication condition, we found no change in perceptions of need supportive behaviours of partners (see Chapter 3).

Participants in both conditions discussed feeling like they were 'free floating', without clear expectations or strategies to achieve their goals, which might explain the somewhat mixed effects of the intervention on PA (i.e. the PA benefits for each condition varied depending on whether someone was an actor (mother) or a partner). Although the study was based on principles of free choice and promoting autonomy, the parents wanted to be told what exercises to do and how often by the researcher, so in this regard they felt the plans were too open to interpretation. Some participants expected to exercise in a face-to-face session and wanted the researcher to be more directive. One reason that parents may have wanted an exercise prescription is because they often alluded to the importance of goals and keeping in mind the end goal of fitness or weight loss. According to Ryan and Deci (2017), there is a distinction between providing controlling structure and providing autonomy-supportive structure. Autonomy-supportive structure involves providing clear expectations, feedback and explaining the link between the behaviour and its outcomes; thus allowing, regulation of behaviour in relation to these behavioural guides. Autonomy-supportive structure can also enhance feeling of competence. It may not be that participants just wanted us to say *"this is what you need to do, you need to run for X minutes on X days*", but wanted more structure, coupled with a rationale for these expectations, and for us to acknowledge their perspectives and feelings towards these guidelines.

As well as providing more structure, some participants wanted us to convey the information more succinctly. They discussed how both intervention workshops and the associated materials felt too long or tedious. The content was not perceived to be novel or sufficiently stimulating to keep some participants interested. In our interviews, participants alluded to the need for mental stimulation in their planned activities. Indeed, intrinsic motivation will only be fostered by activities that offer inherent interest or promote enjoyment including activities that offer novelty, value, or excitement (Brown & Ryan,

2004). Other interventions have used materials perceived to be stimulating, for example, a PA intervention using a Facebook app called the 'Mums Step it Up App', which led to increases in PA in mothers with children under 5 (Kernot, Olds, Lewis, & Maher, 2014). ln their study, daily online tips written with the help of comedians were provided, for example "shopping counts as exercise right? Pedometer says yes". In our intervention, we could have incorporated similar humorous tips and advice. Further, we could have engaged participants with role-playing scenarios to show alternative ways to motivate their partner, examples of stimulating activities involving children, or video scenarios of the communication strategies etc. Even if the intervention materials were improved however, this may have not led to increased PA for several reasons, including salient barriers.

Barriers

The most prominent barriers we identified were work, chores, or childcare commitments and a lack of motivation. For some participants the demands of childcare meant being active was not possible for them. Some participants tackled their childcare barriers by using the plans to take it in turns to look after the children. Many parents may be too tired or (perceive to) have no time to exercise; indeed, caring for young children is demanding both emotionally and physically (Berge, Larson, Bauer, & Neumark-Sztainer, 2011). This finding might explain why some mothers found the demands of childcare too great a barrier to be physically active. McIntyre and Rhodes (2009) outlined key criteria distinguishing mothers who remain active and those who become inactive post child-birth. Specifically, mothers who expect PA to provide stress relief are more likely to be active. Further, control beliefs regarding tiredness, time, social support, and childcare discriminate active from non-active mothers. They suggest control-based interventions could focus on mothers developing a PA routine around pre-set childcare times.

Facilitators

In the interviews parents alluded to how lack of time and childcare were barriers to PA, which may suggest parents felt a lack of control over these obstacles. Hamilton and White (2010a) found lack of time due to childcare commitments stopped parents from fulfilling their PA plans. The present findings however, suggest that the PEEPS intervention helped some participants to address this barrier by identifying opportunities to offer practical support for one another, such as taking it in turns to look after the children, so their study partner could exercise. This aligns with the literature that points to the critical role of partner support as an enabler in the PA of mothers (Miller, Trost, & Brown, 2002; Saligheh et al., 2016).

Engagement

Of particular relevance to the target sample, there was evidence to suggest that planning was particularly helpful for incorporating PA into family life. Parents alluded to feeling that by physically writing down the plan they were more accountable and motivated to engage in PA. This feeling of increased accountability links with the literature as forming a goal intention "I intend to achieve X" results in a feeling of commitment to achieve the goal (Gollwitzer & Brandstätter, 1997). Implementation plans commit the individual to perform goal-directed behaviours when a situation is encountered (Gollwitzer & Brandstätter, 1997).

One concern with forming implementation intentions, is that they may lock participants into a specific behaviour to be performed, and thus, they may stop participants from taking advantage of new opportunities to be active (Gollwitzer, Fujita, & Oettingen, 2004). Although our planning worksheets did not instruct participants to make contingency plans, some parents successfully managed to make back up plans and if they could not complete their planned PA on a set day they shifted their activity to another day. The experiences of some participants in the present study indicate that new opportunities for PA were acted on. Thus, encouraging parents to make contingency plans may be useful.

Some participants exercised on their own (as part of their contingency plan) if they could not exercise together. Alas, some participants discussed how they would not exercise on their own and that they felt more committed and more confident from exercising together via a structured plan as a couple. Although often participants discussed wanting to find activities they could do together as a couple. Some participants reported needing the accountability of a larger group, and the need for more social interactions beyond their partner. A pram walking group for parents could be a free alternative or complement to dyadic interventions, which fulfils the desire for a larger group of people to walk with. Pram walking groups have improved fitness levels and depressive symptoms (Armstrong & Edwards, 2004). Further, the lack of increase in perceptions of need support from partners as a result of the motivation training might explain why participants alluded to the importance of a larger group of supportive individuals.

The interviews revealed participants also had a superficial understanding of what constituted a motivational technique; their descriptions did not align with the 'need supportive style' that the intervention was intended to promote. Intervention resources such as Hancox et al. (2015) were specifically designed to encourage participants to understand how and why to adopt more need supportive approaches to motivating each other. It is possible that had participants engaged more fully with the intervention resources their

motivational skills may have been more well-developed. Future interventions may benefit from educating participants not only in how to develop motivationally supportive behaviours but also helping them to recognise and adjust behaviours that are need indifferent, or even controlling (Bhavsar et al., in press; Quested et al., 2018). Awareness of the broader range of types of motivational style may help participants to better identify what is, and what is not, likely to be need supportive, and in turn, motivationally adaptive.

Findings from this process evaluation suggest that it may not be the training per se that explains the unexpected results. The low compliance to the intervention protocol (e.g., not using resources) reported by many participants may account for why participants felt their partners' attempts at motivational support were either absent or ineffective. In other words, disengagement with the intervention may have prevented the participants from learning how to offer motivational support effectively (i.e., in a need supportive way) in the way that was intended. Aligned with SDT (Deci & Ryan, 1985, 2000), there was also some evidence to suggest that experiencing social support from the study partner as a result of participating in the intervention facilitated more autonomous motivation, but this was not a finding common to all; some participants noted the practical support to be of greater importance. Via the present study we have therefore not been able to provide compelling support for our expectations that training the dyad partners to provide each other with motivational support would further benefit PA engagement by each partner.

Although theory can inform the development of interventions designed to promote PA (Prestwich, Webb, & Conner, 2015), one possible consequence is that an intervention may be less appealing. Indeed, there was some evidence to suggest that the theory-based strategies employed in the intervention may not have been packaged in a way that was appealing to mothers and their partners. In the interviews (Chapter 4), for example, some participants remarked how the intervention workshops and the associated materials felt too long or tedious. Regarding the planning task, we encouraged participants to plan how to support their partner and plan for their own PA, which participants remarked felt repetitive. There was also some evidence that if their child was present during the workshop, this level of distraction meant they needed the workshop to be shorter or divided into modules so they could deal with their child's needs. They suggested that we were providing too much information, rather than getting to the basics of what was expected. In these aspects, perhaps the workshops were too long as we needed to target all relevant theoretical constructs, and this overload of information did not suit the participants' needs. Participants also discussed how they needed mentally stimulating activities (for example, tennis or swimming in the ocean) and thus they

struggled to form implementation intentions as they were limited in the activities they could perform with their partner or with their new child/children. It is important that participants engage with interventions in order achieve success in behaviour change (Prestwich, Kenworthy, & Conner, 2017). We may have found somewhat limited effects on PA, due to this lack of engagement. Increased stakeholder involvement in the design stage of the intervention was thus warranted to increase acceptability to the target population. For example, we could have recruited a group of parents to provide feedback on the intervention materials and pilot the questionnaires.

Even though the intervention emphasised promoting enjoyment over appearance, some participants in the collaborative planning + need supportive communication condition reported their husbands encouraged them by "[telling] me I look good": indicating that the participants did not develop a clear understanding of how to provide feedback to their partner in a need supportive way. This poses a significant challenge for future studies. There is a dichotomy between researchers who want to promote inherent interest and value in PA, while new parents are primarily concerned with exercising to lose maternal weight and "baby fat". Therefore, the messages we are promoting may not suit the needs of postpartum participants.

Future studies

Future studies could explore why mothers want to lose weight and try to draw them away from more introjected motivations (e.g. seeking approval from others) to identified regulations (valuing health and believing weight loss is congruent with health goals). If we divided the workshop into modules and presented it over several weeks, participants may have had a better understanding of motivation. As it stood participants felt the workshop was too long and provided too much information in one session. One mother for example, illustrated how the key expectations needed to be emphasised more rather than covering a range of topics and quizzes. For instance, we could have been more explicit about what motivation is (and is not) so that participants did not have any misconceptions. Future studies need to provide extra role-playing scenarios and explanations to show alternative ways people can motivate their partner, to stop participants feeling they need to be a 'cheer squad'.

It is possible that dyadic PA trials may not be effective for mothers. Other studies involving mothers have shown that involving support partners is rated low on usefulness (Fjeldsoe, Miller, O'Brien & Marshall, 2012). Fjeldsoe and colleagues conducted a PA intervention for women with children under 5, involving phone calls with a counsellor and support from a self-nominated support person. They found short-term increases in MVPA from the intervention. The mothers however, thought that having a support person was not

useful due to competing demands for the support person's time. As 84% of participants in the main trial partnered with their spouse, it may be useful to partner mothers with a PA mentor who does not need to balance their PA support amongst childcare duties.

Future studies could explore whether the barriers, facilitators and implementation issues for participants with younger babies differ from those with older babies. For example, Evenson, Aytur, and Borodulin (2009) explored beliefs, barriers, and enablers to PA among mothers when they were 3 months and 12 months postpartum. They found postpartum women reported not breastfeeding, baby being older, and having a more active baby (who started playing and walking) as enablers of PA at 12 months compared to the same participants at 3 months postpartum. Thus, at later months postpartum participants may find it easier to stick to their PA plans. In Hamilton and White's (2010b) interview study with 40 mothers and fathers living in Queensland, Australia, the participants experienced parenthood as an opportunity to increase PA, especially older parents. Future studies should consider the role of parental age, in relation to the participants' ability to successfully implement an intervention like PEEPS.

Participants reported feelings of constantly "putting out fires" when referring to looking after their children and, despite the focus of the intervention experienced a lack of motivation to exercise. Although this study was designed to suit postpartum parents, future research is required to design programs that can be more easily implemented to fit into the busy and unpredictable life of postpartum parents. Although some participants reported using the taught intervention strategies, this did not always translate into significant changes in PA in the main trial. Alternative research designs (e.g., diary studies, N-of-1 designs) may be helpful to identify when, for whom and why the intervention does and does not work. There is also increasing focus on involving 'end-users' in intervention design (Byrne, 2019). The PEEPS intervention could possibly be improved in the future via a co-design approach, with parents working alongside researchers to create an intervention that is feasible and practical. There was some evidence from our interviews that participants attempted to promote feelings of autonomy in their partner by highlighting values, intrinsic goals for exercise, or positive feelings they would experience from exercise. If participants had kept a diary then we would be able to identify which types of autonomy supportive strategies, they believed themselves or their partner utilised.

Limitations

Many practical challenges to recruit mother-father dyads for interviews were evident. Often one member of the dyad worked full-time (hence, work being a barrier to study

engagement). When we did manage to interview both dyad members together, some of the questions were sensitive (e.g., we asked the parents if they were happy with their choice of study partner and if they felt like a "team"). Participants may have given socially desirable responses due to their study partner's presence. In eight cases only one member of the dyad was interviewed, and so we only captured a one-sided view of that particular dyad experience. Further, we only interviewed study 'completers'. It would have been useful to also interview participants who discontinued from partner-based PA interventions as they may raise different issues to the people who completed the full trial.

The participants were only interviewed once, at the end of the intervention, which means the results only provide a snapshot of their experiences at one point in time. A more comprehensive exploration of the participants' experiences could be captured by interviewing each participant at different stages of the intervention. This method may have revealed the extent to which specific barriers, facilitators and engagement change over time; it may have been helpful to see if there were fluctuations in motivation at different stages of the trial and to explore how these interacted with engagement in the intervention. Participants may have forgotten key experiences or thoughts when reflecting on the intervention retrospectively: interviewing them at different points during the study would help overcome this limitation.

Conclusion

Participants motivated their partners by using prompting questions and emphasising intrinsic reasons to exercise. Situation specific factors influenced engagement with the intervention, such as partner similarity, distance from the partner, and the motivation of both dyad members. A dyadic approach to PA promotion has shown some promise. There was some evidence to suggest that experiencing social support from the study partner facilitated more autonomous motivation. Further, some participants felt exercise was imposed on them or described using controlling strategies to motivate their partner. It is possible that with future tweaks and adaptations to the training, a refined intervention could promote PA increases in this hard-to-reach population.

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Appendix

Table 1

Themes and subthemes relating to each study objectives

Themes	Subthemes	Exemplar participant quote
		Intervention acceptability
Need for exercise prescription		"Um, obviously yes, you [the researcher] were there for the support and the feedback, but for me it helps if someone goes, okay, every whatever, every day or every second day, you are to do this for this long and you will see this result in X amount of days, weeks" (Collaborative planning, Caroline)
	Participants forgetting	"You totally forget that it's even there, and then you don't stick to the program… It's still- That exercise program still sits underneath ... It's poorly lit- poorly- very poorly visible underneath" (Collaborative planning + need supportive communication, Oakley)
The intervention felt tedious		"No, I would say for the planning stage, I know that's what the program is about, but it did get a little bit tedious. …It was a bit of, a bit, um, there was a bit of repetition in it." (Collaborative planning, Brady)
	Accelerometers or measures were an extra burden	"would sort of, um, you know, brush it against my baby, a bit, when I was changing her nappy, or picking her up. Or if I was going out to a work meeting or something, I've got this big jaggy thing on my wrist." (Collaborative planning + need supportive communication, Katarina)
Sparks an interest or awareness of PA		"kind of really made me aware of how many little short walks I do. Like five, ten minutes ones, in the house… Even longer walks I did, if that makes sense…And it made me really aware of how much I was and not, was doing, was not doing sort of at the same time" (Collaborative planning, Rose)
Dislike of online features		"Yeah, I think it's also depends on the people. I'm not a Facebook person. I rarely check my Facebook page. Um, so maybe it would be good to see what sort of social media or what sort of resource, uh, would be best ... would work best for you" (Collaborative planning + need supportive communication, Darla)
		Barriers
Lack of motivation		"I'm very hard to motivate. I've really, really struggled with everything. So, um, it, you know? I think, I think he would take a lot of the, um, uh, um, a lot of the sort of suggestions on that handout. But, um, yeah. I'm just a hard nut to crack I guess." (Collaborative planning + need supportive communication, Grace)

	Appropriateness of study partner	"Interviewer: Can you just clarify again ... why you wanted your sister? Luna: I guess cos we've got a, you know, a closer relationship. And, um, we could exercise together. And, um ... you know, we've both got kids at the same age, so ... that would've made it easier." (Collaborative planning, Luna)
Work, study or chores		"he's been working about 80 hours a week. So, you know, by the time he gets home at 10:00 pm, 11:00 pm, it's too late" (Collaborative planning, Ivy)
Medical conditions		"when at first when I'd do a plan like you're encouraging five days a week, doing two days in a row. I was trying and it was painful. And I wasn't doing it because I was in was too much pain through it." (Collaborative planning, Rose)
Tiredness		"Obviously sleep deprivation, like we'd be knackered by the end of the day and just wouldn't want to do anything" (Collaborative planning, Helena)
Finances		"Um, but then the issue with the gym thing is ... Well, one is financial. Like if you could go to the gym for free, that would be fantastic." (Collaborative planning, Poppy)
Facilitators		
Weight loss		"I think like in my mind- I really, really wanted to lose the pre-pregnancy weight. Like I really ... And that's why I stayed in it. Because even though I found it difficult, I still had in my mind that, you know, I wasn't happy with the fact that I was still wearing maternity clothes." (Collaborative planning + need supportive communication, Janet).
Commitment to the dyad		"when your both, when you're both committed to a certain time or activity to do it's certainly a bit more motivating" (Collaborative planning, Stephen).
	Motivated by exercising as a family	"it's always good to go for a walk as a family and have some time together without- Not sitting around the dinner table or anything like that that" (Collaborative planning, Brady)
	Sense of connectedness	"Relatedness, definitely, when we go for those walks each week, we have really good conversations and that's just really lovely. So, that's improved" (Collaborative planning + need supportive communication, Katarina)
Childcare provision		"Um, so one aspect um whether the baby slept well the night before, um and whether or not I have a kid home during the day, 'cause I have one at school full-time and one at school in kindy, so she goes two and a half days a week. And then I have the baby at home, so making a plan for each set day, in my head I had said, "Well no, I won't be able to do this because um there's too many variables." (Collaborative planning + need supportive communication, Ella)
Personal Motivation	Intrinsic motivation	"but it also made us realize that we were doing it for the right reasons. Not doing it just to you know, to push ourselves to like, to the ends of the earth, but again-… to say that we're doing this because we wanna feel good. We're doing this so that we've got the um, guts, the endorphins pumping through us" (Collaborative planning + need supportive

		communication. Ella)
	Intrinsic motivation – Enjoyment	“And I just really love walking. It's, it's my favourite type of exercise, and there was a really nice bush track near our house. So, it just ticked a lot of the boxes, you know?” (Collaborative planning + need supportive communication, Katarina)
	Intrinsic motivation - Stimulation and relaxation	“I was just gonna say, for some people like myself, you need mentally stimulating stuff; not just it's fun. Like, there's things which are fun but are not mentally stimulating- … But yeah, it's just gotta be somehow- try to incorporate mentally stimulating and even accountable stuff.” (Collaborative planning + need supportive communication, Oakley)
	Value health and fitness	“we do value the health, we do value our ... each other's health because we both want to be around for a long time. So we talk about that all the time. You know, wanting to be fit and healthy for our children.” (Collaborative planning + need supportive communication, Angel)
Visual Materials		“Doing, um, I guess having those little, um, tools to do more explicit visual manner. Like a, like a calendar I mean that we can something, I think, would have been helpful for me” (Collaborative planning + need supportive communication, Grace)
Both barriers and facilitators		
Weather		“The only other time I've had problems if it's been pouring with rain three days in a row or something. I don't like walking in the rain. You know?” (Collaborative planning, Rose)
Distance or convenience		“and they moved. It was five minutes down the road from our place, and then the fitness class changed to, like, 20 minutes away-…And then they go, "Oh, they've stopped coming” (Collaborative planning, Poppy)
	Taking part with spouse	“Well, first of all, we are partners. We do pretty much everything together. We spend the most time together, except when I'm at work. And it makes it easier, when the other person is around you most of the time, to do things together, and to plan things together” (Collaborative planning, Nate)
Having a set routine		“Having a set routine, like, made us more likely to do it, and not having a set routine made- made us less likely to do it.” (Collaborative planning + need supportive communication, Oakley)
	Schedule changed	“Yeah. I guess actually being active, 'cause, I mean, we, we made the plan and that was fine. And then it's just, um, yeah, actually being active when, when-... sort of your schedule changes. Like when I was, um, when I went to the funeral. I mean-“ (Collaborative planning + need supportive communication, Faith)

	Habit	“Takes three weeks to form a habit, so what you want to do is start- get those three weeks behind you, and you should be up and running” (Collaborative planning, Miles)
Engagement		
Motivation components	Emphasising intrinsic reasons to exercise	“like reminding him, "Oh you'll feel better after you exercise." And, um, um, talking about how we, we were wanting to exercise more 'cause ... and why we both wanted to do that and stuff like that.” (Collaborative planning + need supportive communication, Faith~~, 26y~~)
	Use of a questioning style	“Um, it- it made me feel validated, I guess…Because it's- it's always really hard because obviously he's working long hours and then it's all- all about the kids, mainly. So it was nice, it was nice that he'd ask you know, how I was going and if I managed to do what I wanted to do, which was go for a walk… So yeah, it was, it- it, yeah. It- it was nice. (Collaborative planning, Ivy)
	Superficial understanding of motivation	“I'm not really one of these like, "Come on, keep going", you know, I don't respond to that at all. And [my partner] knows that, so probably the less that he says is better.” (Collaborative planning + need supportive communication, Angel)
	Use of controlling strategies	“I will, uh usually find or source, um, a workout that I've got ready to go, just in case I can't get to the gym. And I will make Lisa um, do that as well, whether or not she likes it (laughs).” (Collaborative planning + need supportive communication, Ella)
	Need supportive statements	“exercising and, and running like, your heart felt, like, it wanted to explode…because you hadn't done it in such a long time. But, um, you know, he would push me, and he would say nice things to me to make me feel like, uh, you know, better, and I wanna keep going” (Collaborative planning + need supportive communication, Janet)
Felt exercise was imposed on them		“I'm not sure. I just ... I think he maybe didn't, didn't like exercise. I'm not sure. It's hard to know. He felt like he had a bit too much on his plate perhaps and felt like this exercise was, um, being imposed upon him rather than something that he was choosing to do.” (Collaborative planning + need supportive communication, Katarina)
Commitment and accountability		“I think it's just the fact that it was written down and that's because it- it was sort of a motivation-“ (Collaborative planning, Ivy)
Planning components	Flexibility with plans	“Um, and so I go to the gym as well. That's not on here, um 'cause it says ... If we can't train together, either go by ourselves, or you know-... go take the kids for a walk, but um, we didn't say if uh, anything came up that we weren't, we couldn't do it together, then we'd have to find something else” (Collaborative planning + need supportive communication, Ella).

Easy to set plans, hard to carry them out	"It's pretty thorough. Um, I don't know what you could do to improve it. I think, um, it's all good to have your plans and have everything, you know, and you wanna do this, and everyone want to do this. But just the, you know, everyday life gets in the way of doing all of these plans." (Collaborative planning + need supportive communication, Victor)
Creating visual materials	"we put it onto a whiteboard into just a basic, what day we'd attempt to do things, um, to meet that objective…. So, there's a whiteboard- Sitting near our fridge" (Collaborative planning, Taki)
Promotes conversation	"it made us talk, sit down and actually talk about it, working out our system together" (Collaborative planning + need supportive communication, Utah)
Impact of the intervention	
New ways of thinking	"[I was] worried that if I want to go for a walk every day or every other day, that the kids are gonna- gonna kick up a fight because they have- To sit in the pram for 30 minutes. And it turned out to be completely in my head because the kids were fine-" (Collaborative planning, Ivy)
PA is now more natural	"Uh, yeah, it, to start off it was, um, you knew that there was, we were making an effort to make sure that we-... we did it, but now it just, it seems natural." (Collaborative planning + need supportive communication, Ella)
Program increased their PA	"So we, we've gone from thinking maybe we will just organize ourselves. Um getting on board, to eight week, eight week challenge program that was gonna help us, um, run alongside in the program, but also give us more structure and set classes to go to…As opposed to anything else. Um, to now really loving what we're doing and getting really upset if we have to miss a day because our kids are sick." (Collaborative planning + need supportive communication, Ella)
Integrated motivation	"our whole kind of lifestyle has changed and it's- it's a lot better. I think we're a lot happier for it, being like a bit more active and healthy and stuff like that. So, we definitely, definitely, plan to keep going this way." (Collaborative planning, Helena)

Supplementary Material

Appendix A

Diagrams showing how each theme is connected

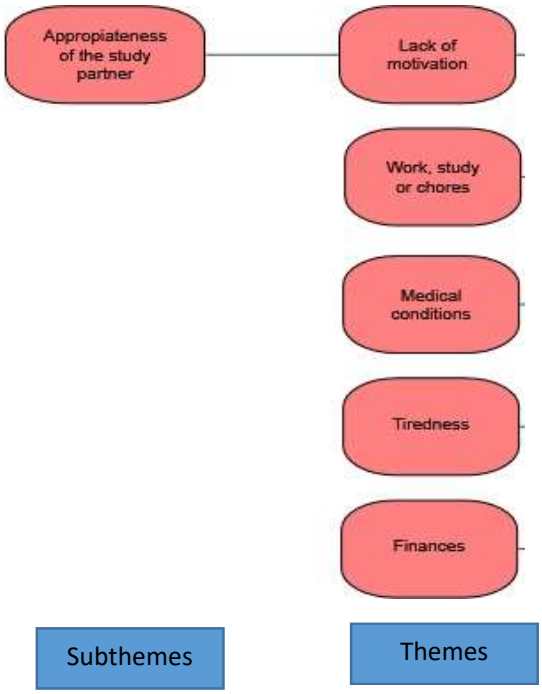

Figure 1. Barriers the participants experienced

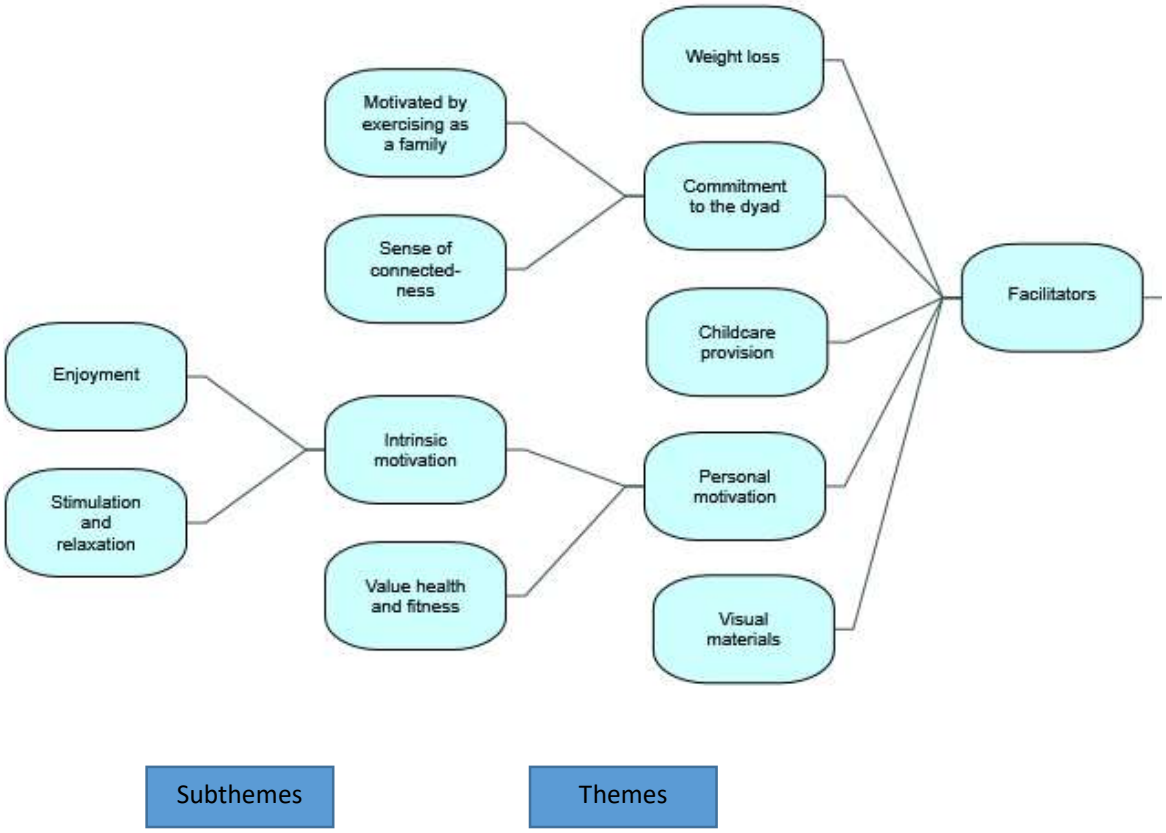

Figure 2. Facilitators to engaging in the intervention

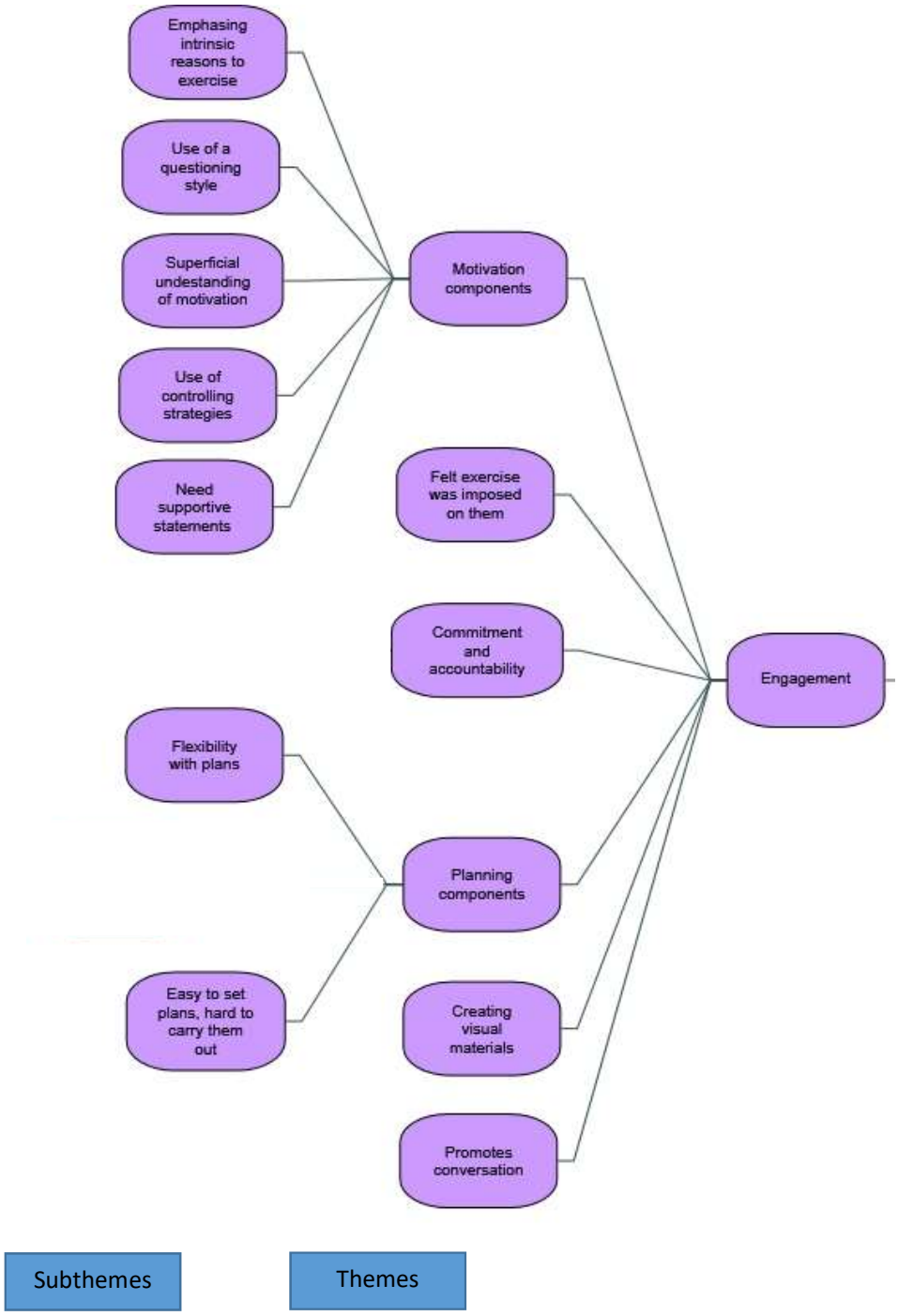

Figure 3. Engagement with the intervention

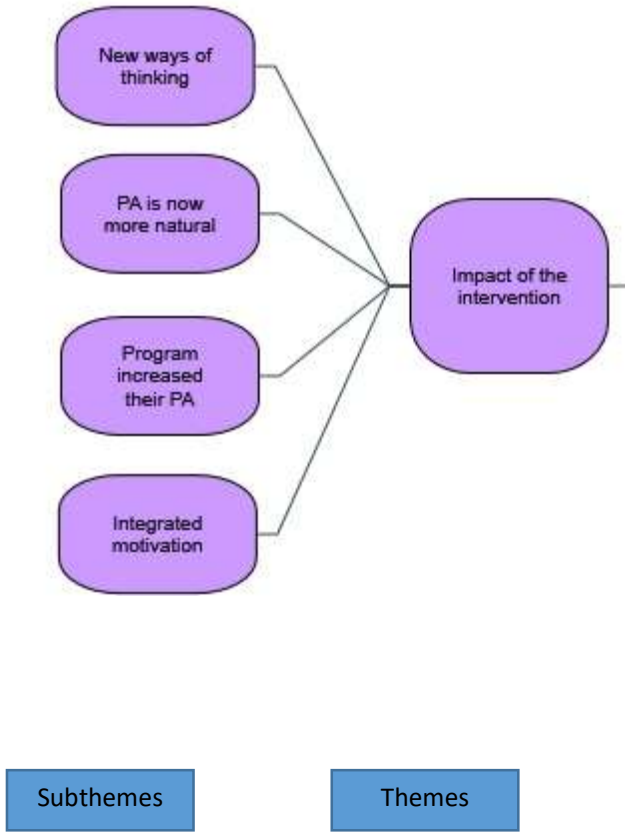

Figure 4. Impact on physical activity

CHAPTER FIVE:

General Summary and Discussion

General Summary and Discussion

Most of the PA literature has focused on individuals or groups. There is promising evidence for utilising dyadic interventions to increase PA (e.g. Castro, Pruitt, Buman, & King, 2011; Prestwich et al., 2012; Winters-Stone et al., 2016). The purpose of this thesis was to assess whether dyadic interventions are effective for PA promotion, by synthesising the available literature and providing preliminary evidence for a dyadic intervention with a population in need of increasing their PA levels. One demographic group at risk of inactivity are parents (Bellows-Riecken & Rhodes, 2008), the onset of parenthood has been associated with a decline in MVPA (Rhodes et al., 2014). Chapter 2 aimed to evaluate the available literature on partner-based PA interventions (including many involving parents) via a systematic review and meta-analysis. Chapter 3 assessed if dyadic PA plans and motivation training can be an effective intervention strategy to increase the PA of postpartum mothers and a study partner (the vast majority were fathers). Chapter 4 explored via interviews barriers to engagement and the acceptability of this intervention. This chapter will summarise key findings within the thesis, with the aim to explore the utility of dyadic interventions for the population at large and for postpartum mothers specifically. After a discussion of the limitations of this thesis, potential future directions for dyadic research will be outlined.

Summary of findings

Chapter 2 was the first systematic review and meta-analysis of dyadic interventions (k=59) to promote PA. Dyadic interventions had a small positive effect on PA, relative to interventions targeting individuals. In line with the TGD theory (Fitzsimons, Finkel, & vanDellen, 2015), this chapter investigated whether shared PA goals between dyad members were associated with larger effect sizes, than non-shared goals. Dyadic intervention had a small, positive effect on PA, compared to comparison conditions including equivalent interventions targeting individuals. Results also showed that shared target-oriented goals (where both dyad members aim for one person in the dyad to increase PA) were associated with larger effect sizes, than other types of goals. Peer/friend dyads were associated with larger effect sizes than other types of dyads across most analyses. Given dyadic interventions promoted PA over-and-above equivalent interventions targeting individuals, this thesis sought to explore their utility for promoting PA in a demographic group at-risk of inactivity, namely, postpartum parents.

The second study (Chapter 3) focused on the implementation of a collaborative implementation intentions (Prestwich et al., 2012) and SDT (Deci & Ryan, 1985) informed intervention targeting the PA of postpartum mothers (*n* = 51 actors; 2 partners) and a study partner (*n* = 49). Participants were randomly allocated to one of three groups: a collaborative planning + need supportive communication condition, a collaborative planning condition and, a dyadic minimal treatment control. The results of this RCT showed a small positive effect on total PA at follow-up (week 12), compared to the control condition, for postpartum mothers in the collaborative planning group and for partners in the collaborative planning + need supportive communication group. Partners also benefited in terms of vigorous activity in the collaborative planning + need supportive communication group. These effects were small but significant, and in line with the findings from the meta-analysis presented in Chapter 2. Caution should be used when interpreting these findings however, as they were significant only when informative priors where used in the Bayesian analysis, whereas when non-informative priors were used the effects were not credible. Chapter 4 focused on an exploration of the barriers to engagement and acceptability of this trial, using interviews with a subset of participants (*n* = 27). The participants alluded to the enablers of childcare provision and increased commitment from being part of a dyad, contextual barriers included lack of motivation and the appropriateness of the study partner. In conclusion, given the small positive effect on total PA at the follow-up, compared to the control condition, for postpartum mothers in the collaborative planning group and for partners in the collaborative planning + need supportive communication group, utilizing a dyadic based approach to behaviour change has shown some promise in a hard-to-reach population, but replication and extensions of this work are needed. To this end, suggestions are offered for future research at the end of this chapter.

Motivational changes

The studies in this thesis build upon the promising results of the meta-analysis in Chapter 2; targeting one dyad member and asking their partner to support them was associated with larger effect size than when both dyad members aimed to improve their own PA together. I suggested in that chapter that if both partners exercise together, they may not be equally motivated and thus a lack of motivation in one dyad member may have spill-over effects to their partner. A research priority was to see how to motivate the PA of both dyad members. Unfortunately, in the RCT neither dyad member increased autonomous motivation as a result of the motivation training. At the follow-up, postpartum mothers in the motivation

+ planning group scored lower on personal autonomous reasons, in the same group and at the same time point, partners scored lower on confidence in their partner's support. The motivation training did not also increase need support. The reason for the lack of intervention effects with regard to motivational variables, as evidenced via interviews with participants, may be because the participants developed a superficial understanding of motivation and sometimes resorted to using controlling strategies to promote PA (e.g., "I will make her do it" or "you have no excuse"). These findings might explain why there was not a significant increase in need support, as not all participants developed a comprehensive understanding of how to support their partner. Nevertheless, some parents felt the demands of childcare and work/chores meant being active was not possible for them regardless of how much their partner supported them. Thus, further training on need support may have not led to greater PA benefits.

As suggested in Chapter 4 a diary would have been a useful tool for participants to report their use of need supportive behaviours. Specific to the dyadic context, partners can report how often they and their partner used the communications strategies. Diary studies have the advantage of gathering data close to the point in time it occurred and are less subject to memory biases (Gagne, 2003). Specific to SDT, diaries could provide an opportunity for the pairs to discuss their use of the communication strategies, how useful they perceived them to be, and whether they would do anything differently next time. This would allow the parents to pinpoint which techniques they are struggling to use. However, it should be acknowledged that this would be an extra time burden on participants so there may be challenges regarding their long-term commitment to completing the diaries (Gagne, 2003).

Another way diaries would be useful, is for the research to pinpoint whether participants are using autonomy support or directive support, as the two can be confused. In the interviews participants remarked how they "checked in" with their partner and reminded them about their goal, as a way to promote social connection. However, although this can be autonomy supportive (e.g. reminding a partner why they want to engage in PA and how good they will feel afterwards), it could also be perceived as controlling and too directive (e.g. reminding them they should be exercising). Gorin et al. (2017) proposed a novel intervention study in which need support was clearly defined and distinguished from other types of support (directive) in how couples are taught to accomplish their goals by working together. For example, "checking in" to see how they are finding their goal or reminding someone about PA could be subtly perceived as both autonomy supportive "this is why we enjoy PA

[providing rationale]" or controlling "it is six o clock why are you not exercising [being imposing]?" Thus, there could be subtle differences in how participants communicate with each other, which could undermine self-determined motivation, depending on how they are perceived. SDT-informed interventions might benefit from further reflection on how to train individuals to be autonomy supportive but not too directive.

Different activities, such as those performed in pairs versus individually, may be guided by different psychological needs (Edmunds, Ntoumanis, & Duda, 2006). As the RCT found no increases in need satisfaction, perhaps SDT based interventions could reflect more on how people can feel competent, autonomous, and connected to their study partner, while pursuing their shared activities. Participants for example, may measure their success in comparison to their partner rather than in relation to their own previous performance (which may undermine competence and relatedness) or settle for a lesser preferred activity to suit their partner (undermines autonomy). Team activities require individuals to coordinate their efforts, values, and interests (e.g., figure skating, synchronized swimming, badminton, volleyball) (Gaudreau, Fecteau, & Perreault, 2009). In these types of shared activities, the "collective" intrinsic motivation of the dyad towards the activity may be important (e.g. "we practice PA for the fun of the activity"). One's own self-determined motivation relates more strongly to positive outcomes when their partner has similarly high levels of self-determination towards the activity (Gaudreau et al., 2009). Hence, finding an activity that both people inherently enjoy in pairs is paramount.

Compared to non-parents, parents of young children may be highly motivated for PA but struggle to be active, due to greater time demands, and hence PA is less of a priority (Solomon-Moore et al., 2017). It is important to understand what type of motives are associated with parents' PA and how to bridge the motivation-PA gap for busy parents (Solomon-Moore et al., 2017). Solomon-Moore et al. (2017) cross-sectional study involved 1067 parent-child dyads reporting on their exercise motivation and wearing accelerometers. In that study, each unit increase in identified regulation was associated with six more minutes of MVPA per day (42 minutes per week). Identified regulation is motivation concerning the personal value placed on the behaviour (Solomon-Moore et al., 2017). Intrinsic motivation was not associated with parents' MVPA in their fully adjusted model. As parents have childcare duties and other priorities, perhaps enjoying the activity is not sufficient to promote PA. Further, in their study, parents' external regulation was not associated with their own MVPA. These patterns of PA are similar to the general population and indicate that PA

interventions need to help parents identify personal value in exercise, the RCT was not successful in this endeavour. Messages regarding the personal value of PA need to be personalised and more relevant and attractive to parents.

Planning

The effects of planning were somewhat mixed in the RCT. Specifically, partners in the collaborative planning + need supportive communication and actors in the collaborative planning condition increased total PA more than the corresponding agents in the control condition. The effect of the collaborative planning condition on total PA for actors was mainly driven by increases in light activity while partners benefited in terms of vigorous activity from taking part in the collaborative planning + need supportive communication group (i.e., they were more likely to have non-zero minutes of vigorous PA). However, no significant differences between conditions were found for MVPA or moderate PA. Possible reasons from past research could explain why planning did not lead to greater PA benefits for moderate PA or MVPA.

How specific a given plan is, appears to be important for plan enactment. Fleig et al. (2017) performed a secondary analysis of 619 action plans from 219 participants. Participants self-reported their use of the PA plans, 6 weeks after cardiac and orthopaedic rehabilitation. Participants were asked whether they engaged in PA alone or with others. Nearly half the participants planned to be active with someone else, often this was a casual partner (e.g. friend, work colleague, or family member) as opposed to a professional trainer (78% vs 16.1%). Whether, participants planned to be coactive with others was unrelated to plan enactment. In contrast, specific references to cues (i.e. when to act) were positively associated with plan enactment. Interestingly, individuals who made a less specific behavioural response (i.e. what to do in response to that cue) were also more likely to enact their plans. Thus, it seems that flexibility of the type of PA is more important than having someone to be active with. They suggest planning interventions should focus on specific context cues but allow flexibility in the behaviour to be performed. In Chapter 3, the collaborative planning + need supportive communication condition mothers may have felt restricted in the activities and this may have undermined their PA. Relatedly, some participants alluded in their interviews to how they were so committed to the dyad they would not exercise on their own. This may have reduced their flexibility in the planned behaviour. Although the workshops aimed to highlight how parents can plan for any activity

or situation, they felt dependent on specific activities (e.g. walking together with the child in the pram) (Chapter 4).

Creating an implementation intention with a partner has been associated with the formation of rather specific behavioural responses "then I…", but less specific contextual cues "When it is…" (Keller et al., 2017). This could be because the partner attempts to keep the planned future situation as flexible as possible to evade anticipated barriers or that the partner helps form a concrete activity of which both partners have a clear unambiguous understanding (Keller et al., 2017). Thus, dyadic plans may be too specific and inflexible regarding the behaviour to be performed. However, although in the RCT the planning worksheet did not instruct participants to make contingency plans, some parents successfully managed to make back up plans to pre-empt and address disruption to plans (Chapter 4). Thus, for some participants, but not all, dyadic plans allowed for flexibility. A systematic review of 11 RCTs found combining action plans with coping plans is more effective than action plans only (Kwasnicka, Presseau, & Sniehotta, 2013). Perhaps, all participants should have received training on how to anticipate and make plans to negate barriers (e.g., clear space in the partner's schedule, so their partner could engage in PA). The experience of some dyads in the interviews suggest that participants would have found this acceptable.

One implication of the findings of the present thesis is that engaging in PA *together*, is not always successful or feasible for many dyads. In Chapter 2 for example, shared system-oriented goals (involving both dyad members aiming to increase their own and each other's PA) was not associated with larger effect sizes than other types of goals. In contrast, aiming for one dyad member to increase PA and their partner providing support was associated with larger effect sizes. In the intervention study, many dyads could not exercise together and created individual plans with their partner taking on a supportive role. Thus, the traditional collaborative implementation intentions "if it's situation X then WE will do Y" could have been adapted to also include individual plans with partner support, when necessary. This thesis could have explored whether dyads engaging in PA, with some group elements (e.g. walking groups with multiple pairs) leads to greater PA change, but due to the restrictions parents faces, coordinating this would have been very difficult. Thus, although there are several advantages to the dyadic approach over traditional groups, intervention efforts need to be tailored to suit postpartum parents.

Theoretical and practical considerations

According to TGD theory, dyads will have greater benefit when they have high goal coordination. For instance, in close relationships if dyads have goals which obstruct each other they will not make effective use of resources (Fitzsimons et al., 2015) (e.g., time, opportunities for PA). It is possible for some dyads it is easy to plan where and how they will engage in PA, and they may not require a PA intervention to do this. This may be because they have chosen a romantic partner who has similar goals and they facilitate each other's PA pursuits naturally. For other dyads, they may be able to pursue a PA goal effectively, only after much planning, and juggling of competing demands (Fitzsimons et al., 2015). Parents have many time commitments and thus planning may be more crucial for them. For example, in Chapter 4 participants discussed how they used their plans to take it in turns to look after the children so they could exercise or have personal time. We found in Chapter 2 that setting goals for both dyads members may not always be effective and we suggested in that chapter that future studies should explore whether certain behaviour change techniques e.g. goal-setting (action plans) are more effective when used amongst different types of dyads who pursue different types of goals. We have shown that planning for PA (without motivation training) results in increased PA for mothers, while partners only benefit from planning if they have additional motivation training (Chapter 3). Thus, it may be that partners need motivation training in order to coordinate their plans effectively. For instance, autonomy includes encouraging choice for their partner so with high autonomy, dyads may be more likely to find an activity they both enjoy. Although speculative, as goal coordination for some dyads may require a great deal of resources (Fitzsimons et al., 2015), motivation training may have felt like an extra drain on mothers' limited resources. Thus, intervention efforts need to be tailored to suit postpartum mothers.

Future directions

Stress and emotions. Positive affect could influence how often people mobilize planning support from their partners (Keller et al., 2017), and this may be particularly relevant to postpartum parents. If mothers for example, experience positive emotions then they may more readily discuss their plans with their partner. Given that having a child is fraught with many new challenges to overcome (e.g. childcare commitments, lack of time; Hamilton & White, 2010), parenthood is associated with increased stress. Ego depletion theory (Baumeister, 2002) emphasises how under stressful circumstances, positive affect is a resource facilitating regulation of behaviours (e.g. planning for one's own health). Thus, as parenthood is associated with increased stress, promoting positive emotions is warranted in

future studies to promote planning for PA and counter ego depletion. Keller et al. (2017) collected data from 209 prostate cancer patients and their partners. They measured how often participants formed individual and dyadic implementation plans for increasing pelvic floor exercises. They found that patients' positive affect was positively associated with dyadic planning, negative affect was negatively associated with dyadic planning. Thus, collectively these studies illustrate that parents (a population under a great deal of stress) would benefit from increased positive affect as this would allow them to give and harness support from their partner in making dyadic plans.

Similarity. How readily people mobilize support from their partners could be influenced by their similarity to the partner. Smith and Holloman (2013) compared children who received an 8-week *Just for Kids! Curriculum* through their teacher in class, to those receiving the same content by individual teen mentoring. In terms of lifestyle support, the individually teen-mentored children received stronger support and they improved their PA and diet. The meta-analysis in Chapter 2 found that peer/friend dyads were associated with larger effect sizes across most analyses. Future studies could explore whether there are greater PA benefits when partnering with a peer with similar household responsibilities. Parents might feel more readily able to improve PA if mentored by another parent of a similar background or the same gender. Future studies could explore whether mothers improve PA more when paired with another mother, as opposed to their spouse, or vice versa. Chapter 4 illustrates how participants felt similarity was important (e.g. in terms of having children of the same age or circumstances) between study partners. Some participants did not have a friend or family member to partner with. Hence, the suggestion to pair mums together in a "buddy system" seems warranted in terms of future dyadic interventions. This approach would have its own limitations, as strangers may not get along on a personal level and they would not have the convenience of living together. Hence, future studies could explore whether being paired with a stranger results in similar gains in a PA intervention compared to pairing with a familiar person (e.g., spouse).

Goal disengagement. In some cases, similarity may be counterproductive to PA. In a daily diary study (Lüscher, Berli, & Scholz, 2017), higher daily goal disengagement by one partner contributed to a decreased likelihood of the other partner meeting their PA goal. Lüscher et al. (2017) suggested as a research priority to explore whether partners who initiate a new behaviour together feel and perform differently if one partner subsequently loses interest in the behaviour. In Chapter 4 participants alluded to how they and their partner were

"the same type of people" and both were "not big on exercise". It could be that participants disengaged from the goal, however, it may be that they never engaged or did not feel intrinsically motivated. Future studies could compare the detrimental effects of having a partner who disengages from the goal versus one who never engages with the goal.

Role models. Participants selected an inactive partner, which sometimes meant they settled for someone of a similar low PA status. Future studies could explore whether greater PA is achieved through pairing an inactive individual with an active partner. In Chapter 2 larger effect sizes were found in studies targeting peer and friend dyads than studies targeting different types of dyad. In a relatively high proportion of these studies, participants were allocated a PA role model/mentor. It may have been useful in the RCT to pair participants with a physically active role model of a similar status who could serve as their inspiration (e.g. a physically active mother who balances PA with the demands of childcare). These role models could work with the participants to provide support and promote PA.

Dynamic dyads. In the trial, dyad members had to keep the same partner throughout treatment. For participants partnering with a friend, it may have been practical to allow them to change partners during the study, so if they felt their study partner was not suitable (as was occasionally the case; Chapter 4), they could choose someone else. The review did not explore dynamic versus stable dyads, as the authors are not aware of studies that allowed people to change partners.

Peers versus professionals. The RCT relied on naturally occurring dyads for example, friends and family members, however, there is a plethora of research focusing on PA counselling or motivation interviewing for mothers delivered by a trainer counsellor. For example, the Albright et al. (2014) intervention involved 17 telephone calls with mothers after they set MVPA goals. PA gains, self-reported at 12 months, were significantly greater in this arm of the intervention, compared to mothers who were given access to a PA website with no counselling. In the meta-analysis studies were excluded where one member of the dyad was a health professional. It may be interesting for future studies to compare motivation training provided by a friend or family member to training provided by a health professional. Perhaps, participants may have felt increased confidence and motivation, if the feedback and instructions were delivered by a professional.

It may be that participants did not feel they had sufficient structure from taking part in the intervention with their spouse or friend. Structure concerns whether expectations are

clear, feedback is provided, and the links between the behaviour and its outcomes are explained (Ryan & Deci, 2017). The authors relied on the participants to provide PA feedback to their partner. There was some evidence of partners providing this feedback, however, participants in the interviews alluded to the need to be told what to do (e.g. if you increase your PA to X times a week, then you will see X result), and needing more emphasis on the key expectations (see Chapter 4). Thus this desire for greater structure was not fully met from interactions with their study partner. However, health providers such as physicians, often do not engage in PA promotion, due to lack of financial incentive for doing so (Joy, Blair, McBride & Sallis, 2012) and they may be limited in their delivery capacity. It may not be financially feasible for the long-term, to engage clinicians to provide tailored support to participants.

Relationship quality. Future studies should explore similarities between dyads' scores when they receive motivation training and whether any observed effects are moderated by changes in relationship quality. In Chapter 4, participants alluded to how having a close relationship with their partner and similarity in circumstances was important for intervention engagement. It could be that in close partners any positive effects on PA in one partner are likely to affect their partner's corresponding values. Howland et al.'s (2016) survey study of 200 romantic couples for example, found a positive relation between actors' behavioural intentions and partners' subjective norms. This effect however, was only found for actors who had higher relationship quality.

Limitations

There are a number of potential limitations that need to be acknowledged. In relation to the meta-analysis, there is the possibility that studies that should have been included were omitted as only one author screened for eligible studies. Given the results of Egger, Smith, Schneider, and Minder's (1997) test and trim and fill analyses, there was also potential publication bias. Attempts to gather the 'grey literature' were unsuccessful, the corresponding authors of included studies were contacted, but none shared unpublished studies meeting the eligibility criteria.

Limitations of the RCT include how some participants made individual *implementation intentions* (despite the researcher's advice) and others selected a partner who lived separately or far away. Also, most participants watched the workshop online (n = 84), hence the extent to which they engaged is unknown. Further, when one dyad member

discontinues from an intervention, their partner may follow suit. In such cases, there may be repercussions for the motivation of their partner. In this respect dyadic studies are limited regarding the difficulty of recruiting two people who want to take part and keeping both satisfied. Another concern is that sometimes participants signed up to the trial as their partner wanted to join, or they felt exercise was imposed on them rather than something they were choosing to do (as discussed in the interviews). This may have been the case with other dyadic studies, as it is unlikely both partners are motivated for the same reasons. It may be more useful in this instance, to increase the PA of one dyad member and ask their spouse to support them (with no obligations of them exercising themselves).

In retrospect, the training material from a SDT perspective focused more on personal as opposed to relational autonomous motivation, and this limitation should be addressed by future research. In Segar et al.'s (2017) qualitative study, many mothers discussed walking as a time to connect, socialise and bond with significant others. In their study they enjoyed walking with friends due to having shared experiences, such as both being overweight. No significant differences between groups were found for relational autonomous motivation in the RCT, although in the interviews, some participants spoke about walking with their family as having "us time".

Limitations of the interviews include how participants were only interviewed once, post-intervention, so the results only reflected their experiences at one point in time. Thus, changes in barriers, facilitators, and engagement over time could not be assessed (for example, motivation may have fluctuated over time). Also, when both dyad members were interviewed together, some of the questions were sensitive and may be influenced by social desirability (e.g. if they were happy with their choice of study partner).

Key Recommendations

While there is a promising and growing field of research on dyadic interventions, several considerations need to be made for future dyadic research. Firstly, the actor-partner interdependence model (Cook & Kenny, 2005) should be used wherever possible in dyadic research. We used this approach in our trial, however, none of the studies in our review used this approach. This method retains the participants' individual scores, while treating them as being nested in a dyad. This allows for the estimation of both individual and dyadic factors. We also found in the review that it might be more effective to target one person and encourage their partner to support them to increase PA, ensuring they both hold the same PA

goal for the main target. Our interviews (Chapter 4) showed how participants felt restricted in activities they could do together as a couple with a new baby, so they often exercised separately. Future dyadic interventions should also emphasise how dyads do not need to exercise together. Participants in our intervention could create a combination of plans to exercise both together and/or separately, this limited our ability to compare the different goal types. We recommend researchers test different types of dyadic goals to see whether one specific goal or a combination of dyadic goals drive any observed effects of dyadic interventions on PA.

Recommendations around applying these interventions to promote PA are tentative given the mixed findings. We found that a variety of social media advertisements and face-to-face contact was needed to recruit the target sample. Recruitment by Facebook was advantageous for this population, as parenting groups were often happy to share advertisements. Alas, it was often the mother who engaged with the advert, and this meant that their partner sometimes felt coerced into joining (see, Chapter 4). We recommend separate advertisements for fathers, possibly in consolidation with a group of fathers who can critique the advertisements. As discussed in the interviews, some participants felt that exercise in the study was imposed on them. Participants sometimes expressed an interest in discontinuing the study due to not increasing PA or struggling to engage with the intervention. We emphasised that even if they felt this way, it is still useful to measure their PA, as we wanted a realistic interpretation of whether the intervention worked, rather than biased results from only a handful of participants who found the intervention easy to engage with. This may help explain the lack of consistent significant effects, but means our sample is more representative. Some participants completed the measures but did not engage with the intervention. In contrast, some participants felt that completing the measures was the part of the program they found hardest to engage with. We recommend that researchers emphasise the purpose of a "research study". We needed to emphasise how the program provided a scaffold in which to structure PA but relies on the scientific assessment of PA and is not to be confused with a prescribed exercise program at a gym or exercise facility.

A further key recommendation is to focus on how to translate traditional psychological theories, such as SDT, to the dyadic context. It might be, for example, that competence ("feeling effective in the environment") needs to be addressed at the dyad-level, to make the dyad feel that as a pair they can master a behaviour, rather than operating as two independent agents with differing abilities. In the same way, for the behaviour to increase

relatedness the dyad may need to feel that as a couple they have friendships with others (e.g., other couples), rather than solely addressing the relationship between the dyad. For instance, couples who value independence from their partner and rely on their friends for connection and closeness, may wish to increase relatedness among a larger group i.e., between the dyad and their close friends. A second recommendation is to explore, the causal mechanisms behind the effects of dyadic interventions on PA. Finding mechanisms behind behaviour change, will allow researchers to target specific behaviour change techniques which promote PA. For example, perhaps taking part with a partner in a PA intervention increases self-efficacy which results in increased PA. Given we found in the collaborative planning + need supportive communication condition, partners had greater total PA but had lower confidence in the mother's ability to support them; causal mechanisms, such as confidence in oneself or the partner, need to be further explored in relation to their effects on PA. The effects of applying dyadic interventions to promote PA should be interpreted with caution given the mixed and unexpected findings, until we can more fully understand the causal mechanisms. Finally, we explored dyadic interventions, in general, and then focused on a dyadic intervention, involving a combination of different types of dyadic plans and motivation training. What is not known is which types of plans work best, which type of behaviour change techniques are most effective in promoting PA for dyads, or whether it is more constructive for the techniques to be implemented by the researcher or the dyad partner (e.g., reviewing the participant's goals, providing social support). The systematic review would have benefited from exploring the behaviour change techniques used in the studies and who implemented them. In the interview study, participants discussed how they wanted the researcher to set goals, prompt them to PA, and provide exercise prescription. Alas, partners could be encouraged to help their partners make new plans, provided different techniques to prompt their partners' PA, and informed how to find resources with example goals and activities.

Strengths

This program of research has several strengths. Firstly, a range of methods were utilised to explore dyadic interventions to promote PA. In Chapter 2, the literature was summarised using a systematic review and meta-analysis, the first review of dyadic interventions to promote PA. A strength of this review was the use of a theoretical framework (TGD) to code goals and explore their moderating effects. Broad search terms were generated based on previous reviews, and multiple databases were utilised, including dissertations. To

ensure accuracy, key elements of data extraction were double-checked by second coders. To the best of our knowledge, this thesis also presents the first dyadic RCT targeting fathers to promote mothers' PA, as fathers are the often-neglected half of the spousal couple. This trial has shown it is possible to engage postpartum mothers (n = 51 actors; 2 partners) and to a large extent their spouses (n = 43), to both a 12-week program and interviews evaluating its effectiveness. This thesis was original, as the integration of SDT and collaborative planning has never been applied to mother-father dyads. The approach was inclusive as mothers could self-select any significant other. Strengths of the study included the its RCT design, the choice of face-to-face or online, and testing of two intervention conditions against a minimal treatment condition. Throughout this thesis, both self-reported and objective measures of PA were used. In Chapters 3 and 4, both quantitative and qualitative methodologies were used to evaluate the trial.

Conclusions

The series of studies in this thesis explored the potential of dyadic interventions to promote PA across different types of dyads and in one specific population - postpartum mothers. This thesis was designed to inform the field of research on dyadic interventions and couples-based approaches to health promotion. The meta-analysis and the pilot study showed a small positive effect of dyadic interventions on PA promotion. Realising there were somewhat limited effects of collaborative planning and SDT training on the PA of mothers and a study partner, we sought to explore their perceptions of the intervention using interviews. Collectively, this thesis shows that it is possible to recruit a hard-to-reach population, but the challenges of parenthood make it very difficult to promote sustained PA in this group.

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