Full title:
A review of the 6-Minute Walk Test: its implication as a self-administered assessment tool

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Abstract

Background:

Promoting self-management and monitoring physical activity are important strategies in chronic heart disease (CHD) management. The six-minute walk test (6MWT) is a commonly used sub-maximal exercise test for measuring physical functional capacity.

Aim

The aim of this paper is to provide a comprehensive review and critique of the current literature on 6MWT in relation to monitoring and measuring physical functional capacity as well as exploring the potential of the protocol to be adopted as a self-administered exercise test.

Method

The Medline, CINAHL, Science Direct and the World Wide Web using the search engine Google, were searched using the key words "six-minute walk test"; "6MWT"; "exercise test", "heart disease"; " physical functional capacity", "chronic heart failure" from 1985-2008. Articles administration, reliability and validity of the 6MWT were sourced.

Findings of the integrative literature review

The 6MWT is a simple, safe and inexpensive sub-maximal exercise test. The 6MWT distance is strongly associated with functional capacity, and it is a useful prognostic tool. To date, the capacity for self-administration of the 6MWT has not been investigated.

Conclusions

Adapting the 6MWT as a patient-reported outcome measure may enhance the capacity, not only for clinicians to monitor functional status, but also promote self-management by enabling individuals to monitor changes in their functional capacity.

Coronary heart disease and physical activity

Coronary heart disease (CHD) is the leading cause of death worldwide and has reached epidemic proportions.(1, 2) The prognosis for people with CHD is closely related to their physical functional capacity.(3) In CHD, physical functional capacity is influenced by pathophysiological changes and symptom burden.(4) It is known that moderate physical exercise (150 minutes per week), not only reduces the risk of CHD by approximately 30%,(2) but can also reduce symptoms associated with the disease and decrease mortality. In spite of this fact, up to 60% of the population globally are not performing sufficient levels of physical exercise.(2) As a consequence, promoting physical activity and monitoring physical functional capacity has become an important strategy in preventing and managing CHD. There are well-documented barriers in engaging in physical activity and these factors can be intrinsic, for example low self-efficacy, and extrinsic such as the inaccessibility of resources. The maximal exercise test is a test with progressively increasing work rates using exercise equipment, such as a bike or a treadmill, until volitional fatigue occurs determining maximal oxygen consumption.(5) The purpose of a maximal exercise test is to assess the peak rate of oxygen consumption, anaerobic threshold and cardiopulmonary function. However, its cost, safety issues, risk of adverse outcomes and the fact that these tests need to be performed by an experienced health care professional often limit the use of maximal exercise testing. Compared to the maximal exercise test, submaximal exercise testing has a lower level of intensity and does not require the use of technology. When assessing the application of maximal or submaximal exercise testing, there is a need to appraise the strengths and limitations of each of these approaches.

The six-minute walk test (6MWT) has been devised as a practical sub-maximal walk

test, measuring the distance that patients walked on a flat hard surface over a period of six minutes as a reflection of their functional capacity. The 6MWT is a self-paced exercise test. Subjects are allowed to stop and rest during the test and resume walking when they feel comfortable to do so.(6) The 6MWT is commonly used in clinical settings as a single measurement of physical functional status and as an outcome measurement of the response to treatment interventions in patients with moderate to severe heart or lung disease.(7, 8) The 6MWT has also shown a value in predicting morbidity and mortality.(9, 10)

Aim

The aim of this paper is to provide a review and critique of the current literature on the 6MWT in relation to measuring and monitoring physical functional capacity, as well as discussing the potential of the 6MWT as a self-administered tool.

Method

A modified integrative review method was used to provide a critique of the 6MWT literature. The modified integrative review summarises and analyses both experimental and non-experimental studies to provide a more comprehensive understanding of the study phenomenon and to identify the needs to inform future research studies.(11) A literature search was conducted on studies reporting the 6MWT in people with CHD using the Medline, Cumulative Index of Nursing and Allied Health (CINAHL), the Science Direct databases and the World Wide Web using Google search engine. Reference lists of retrieved articles were hand searched for any additional references. The key words included were “chronic heart disease”; “chronic heart failure”; “walking”, “exercise-test”, “six-minute walk test”; “6MWT;” and “physical functional

status. Studies reporting the use of the 6MWT as an outcome measure, without methodological considerations, were excluded from the review.

Findings of the integrative literature review

The search strategy, yielded 386 publications from 1985-2008. Using the selection criteria of studies reporting administration, reliability and validity of the 6MWT, 34 met the inclusion criteria. Key issues derived from the literature are discussed below.

The Six Minute Walk Test

The 6MWT test was first developed by Balke in the 1960s (12) to evaluate functional capacity. The 6MWT is a simple test that measures the distance walked during a defined period. The duration of the walk test was initially 12-minutes. Different versions of the walk test have been tested for their correlation to the gold standard of graded, symptom limited exercise tests, such as treadmill exercise tests.(1) Studies have demonstrated that a 3-minute walk test and the 6MWT performed as well as a 12-minute walk test.(13, 14) Their reproducibility are also similar.(13) However, when the duration of a walk test is under 4 minutes, the result is not sensitive enough for evaluating differences in distance walked.(15) The 6MWT is a sensible compromise and is currently the most commonly used walk test.

The 6MWT was first used as a standard test in the clinical settings of chronic respiratory disease and respiratory failure.(8, 16) The test is easy to perform, interpret and particularly useful in conditions such as chronic heart failure (CHF), that are characterised by diminished functional capacity.(8) The first studies assessing the 6MWT in patients with heart disease, were undertaken by Guyatt *et al.*(17) and Lipkin

et al.(18), reporting that the 6MWT can differentiate the most compromised heart failure patients from the less severe cases according to the New York Heart Association (NYHA) functional class classification.(9, 10)

Peak oxygen uptake, functional capacity and the 6MWT

Functional capacity is often expressed by peak VO_2 during maximal exercise testing.(19) Peak VO_2 is a strong indicator of the severity of CHF, (20) as well as an independent predictor of mortality. The endorsement of peak VO_2 assessment in the cardiac transplantation guidelines has also confirmed its prognostic value.(20) Peak VO_2, assessed during the 6MWT, has shown similar reproducibility and accuracy when compared to the shuttle walk test, an incremental form of exercise testing. (21). The peak VO_2 is approximately 10-20% higher during the maximal exercise test compared to submaximal exercise testing.(6) In people with advanced conditions, maximal exercise testing may be contraindicated due to significant impairment in functional capacity. In this case, assessing the highest VO_2 from a submaximal exercise test is useful but can be less predictive of prognosis.

There is consensus that the 6MWT is a simple, safe exercise test.(4, 18, 22, 23) Strong correlations between the 6MWT distance and the peak VO_2 (r=0.56 to r=0.88) have been reported.(23) Faggiano *et al.*,(23) demonstrated that in a quarter of the participants, their VO_2 during the 6MWT, was higher than their anaerobic threshold, that is their peak VO_2.(24) Another study performed by Riley *et al.*, showed a similar result, that is the VO_2 during the 6MWT is similar or higher than peak VO_2.(23) Riley *et al.*, did not measure VCO_2, therefore the participant's anaerobic threshold was unknown. These two studies suggested that in people whose physical functional capacity is severely impaired,

an exercise test of a submaximal nature could be a reflective of the results obtained from a maximal exercise test.

Prognostic value of the 6MWT

There is no consensus regarding the prognostic value of the 6MWT. As a consequence of a “ceiling effect”, that is where the test result is too high to detect further significant improvement, both clinically and statistically,(25). The 6MWT has perhaps its greatest application in the CHF population, where functional capacity is impaired and periods of decompensation are common. Most studies examining the prognostic value of the 6MWT have been done in people with CHF. The prognostic value of the 6MWT was first reported by Bitter et al.(26) in the Studies of Left Ventricular Dysfunction (SOLVD) study, enrolling 898 participants with CHF over a follow up period of 242 days. In Bitter *et al*.’s study, the mortality rate was 10.23% in individuals who walked less than 350 metres, and 2.99% ($p<0.01$) in participants, walking more than 450 metres on a 6MWT. Subsequent studies have demonstrated that the 6MWT distance is prognostically useful in predicting mortality and hospitalisation.(26, 27) In one study examining the relationship between the 6MWT distance and outcome of a population of stable outpatients with CHF, 541 participants undertook the 6MWT at baseline. Following a median of 32 months follow up, a shorter 6MWT distance at baseline (<200 metres) was associated with significantly higher risk (59% higher, $p<0.001$) of all-cause mortality.(28) However, studies comparing the 6MWT with other tests, such as symptom limited cycle ergometry (22) and standard indices of cardiac function, show only a moderate correlation between the 6MWT distance and exercise capacity.(8, 22, 29) These studies suggest that the 6MWT distance is not an independent prognostic indicator, but a complement or substitute for the peak oxygen uptake (peak $VO_{2)}$ or

NYHA-functional class.(22) Although, the 6MWT may not be a standard, independent prognostic indicator, compared with peak $VO_{2,\ assessed}$ during maximal exercise testing; it certainly provides valid and important information regarding individual's functional capacity.

The 6MWT distance in CHD population and in the healthy adult

The distance walked in the 6MWT has been used in people with heart disease to evaluate functional capacity. In a study with 315 participants, with moderate to severe heart failure, the 6MWT distance ranged from 134 metres to 686 metres.(28) Generally a distance of less than 300 metres is considered as the threshold for increased risk of mortality, with only one study suggested 200 metres.(30-33) The discrepancy of the threshold distance may be due to the difference in the 6MWT protocol used, such as the use of encouragement. Stopping and resting during the test that are known to influence the walk test distance.

In order to derive normative data and assist in interpreting test results, the 6MWT distance in the healthy population provides a useful reference point. Four published studies have provided normative data in healthy adults.(30) Enright and Sherrill(30) have developed equations to calculate the distance walked by healthy adult during 6MWT. These are:

- 6MWT distance = (7.57 X $height_{cm}$) – (5.02 X age)- (1.76 X $weight_{kg}$) – 309m for men
- 6MWT distance = (2.11 X $height_{cm}$) - (2.29 X $weight_{kg}$) -(5.78 X age) + 667m for women

These two equations are based on 6MWT performance of 117 healthy man and 173 healthy women aged 40 to 80 years. In this study, the mean 6MWT distance was 576

metres for men and 494 metres for women.(31) Among the other three studies, the study by Gibbons *et al.*,(32) which recruited a sample of young participants with a mean age of 45.1 years reported the longest mean 6MWT distance of 698 metres. Steffen *et al.*,(33) studied a sample of elderly people with a mean age of 74.1 years. In this study the mean 6MWT distance was 505 metres for men and 467 metres for women. Trooster *et al.*,(8) reported that a mean 6MWT distance of 613 metres where the average age of participants was 65years. These four studies not only provide a reference point for interpreting the 6MWT distance. These data also show the relationship between anthropometric variables, gender, age and the 6MWT distance.(31, 34) The 6MWT distance is inversely correlated with age,(31) which is greater in men than women by an average of nearly 76 metres.(14, 29, 35)

Practical application of the 6MWT: methodological considerations

From the existing literature, the 6MWT protocol varies from study to study. Key variances in protocol relate to using encouragement and the use of practice tests before formal assessment of the 6MWT distance. Besides the anthropometric variables mentioned in the previous section, the 6MWT distance can certainly be influenced by the variations in 6MWT protocols. Some of the methodological issues to be considered in interpreting results are discussed below.

The learning effect

The distance walked during the 6MWT tends to increase (+19 metres when the two tests are done 30 minutes apart) and over the first five walks ($p<0.001$). The largest improvements in distance walked is seen over the first 3 walks.(36) There is no significant difference between measurement taken 30 minutes and 24 hours apart ($p=0.99$).(29). These observations relate to the learning effect. It is calculated that the

minimum variation in the 6MWT distance that can be considered as an expression of a real variation of functional capacity is approximately 10% of the average of two consecutive tests.(29, 37) Therefore, it is commonly agreed that one or two practice 6MWT can be useful before using it to measure physical functional capacity.(4, 23, 30, 38)

The use of encouragement

Several studies have used standard verbal encouragement during the test, (9, 14, 29, 34) while others have not.(9, 14, 39) The use of encouragement during a 6MWT has an impact on the test result.(6) However, the reproducibility of the 6MWT result, with or without encouragement, are similar.(6) Although the American Thoracic Society (ATS) 6MWT guideline recommends using standard encouragement during the test,(40) the decision regarding the use of encouragement during the test should depend on the nature and purpose of the study.

Reliability of the 6MWT

Reliability refers to the ability to measure the same result on repeated tests. (40) The intraclass correlation coefficient (ICC) is a measure of reliability. An ICC of greater than 0.75 is considered adequate and 0.90 is considered excellent.(40) A study undertaken by Dermers and colleagues, (40) in the Randomized Evaluation of Strategies for Left Ventricular Dysfunction (RESOLVD) pilot study, assessed the reliability, validity and responsiveness of the 6MWT. The participants in the RESOLVD pilot study were a group of stable CHF patients with NYHA II-IV symptoms. In this study, the 6MWT was repeated twice at each of the three measurement times over a period of 34 weeks, the test-retest reliability was high with an ICC of 0.85.(4, 34, 41) Other studies have reported the ICC of repeated 6MWTs ranging from 0.75 to 0.97. (4) Only one

study reported a significant difference between the distance of two consecutive 6MWTs, leaving these authors to conclude that the 6MWT distance to be not reproducible in their study.(40) In this particular study, the period between two tests was unknown, it is also not known if learning effect was another contributing factor to the result of this study. Despite the variations among the 6MWT protocol in each study, such as whether there was a practice test, or encouragement was used existing data suggests that the 6MWT is a reliable measurement of functional capacity.

Validity of the 6MWT

Validity describes the relationship between an attribute under evaluation and other attributes.(40) Sousa and colleagues studied the utility of the 6MWT in Chagas disease. The results from their study suggested that there is a negative correlation between the 6MWT distance and the increased circulating levels of monocyte chemosttractant protein (MCP-1, r=-0.358, p=0.04);(42) a negative correlation between the 6MWT distance and natriuretic peptide type B (BNP, r=-0.349, p=0.04); and a positive correlation between left ventricular ejection fraction and the 6MWT distance (r=0.451, p=0.004) (42).The 6MWT has also been compared with other assessment tools such as the NYHA-functional class and measures of health related quality of life (HRQoL), including the disease specific Minnesota Living with Heart Failure Questionnaire (MLHFQ)(34) and the physical functioning domain of the generic HRQoL measure, the Short Form-36 (SF-36).(40) The 6MWT has also been shown to have a weak and inverse correlation (r=-0.39) with the MLHFQ, and likewise, an inverse correlation (r=-0.45) between the 6MWT distance and the NYHA scale (p=0.058).(34) The correlation between the 6MWT distance and the SF-36 physical functional section was 0.623 (p<0.001).(40) Questionnaires examining HRQoL are subjective, multidimensional self-

report tools, consisting of other domains other than physical functioning. The physical function domain of the SF-36 is better in reflecting physical activity; therefore, a weak correlation between 6MWT and QOL, and stronger correlation between 6MWT and SF-36 physical function section are expected. These data discussed above, suggests the 6MWT is a valid measurement tool for physical functional capacity. However, it focuses explicitly on physical functioning and is not representative of other aspects of HRQoL

Responsiveness of the 6MWT

The responsiveness or sensitivity to change assesses the ability of a test to measure change over time or the ability to measure the effectiveness of treatment.(38) In one study, the 6MWT was found to be more sensitive in evaluating the effectiveness of an exercise intervention compared to Duke Activity Scale Index (DASI) (r=-0.42).(40) In the RESOLVD pilot study the standardized means were statistically significant for participants who were receiving candesartan and enalapril.(43) A similar result was found in another double blind, randomized, placebo controlled trail, where the mean 6MWT distance increased by 37.1 metres ($p<0.001$) over a ten weeks follow up in the intervention group receiving perindopril.(1) However, the utility of 6MWT in assessing the effectiveness of pharmacological interventions is not convincing. The systematic review by Olsson,(1) summarized all clinical trails done on the 6MWT in assessing the effectiveness of treatments up till 2004. There were 46 placebo-controlled trials, 39 pharmacological interventions and 7 non-pharmacological interventions. The changes in the 6MWT distance before and after intervention is significant in four out of the seven non-pharmacological interventions, and only significant in nine out of the 39 pharmacological interventions. The majority of the pharmacological trials, showing no significant changes in the 6MWT distance, were done in assessing the effectiveness of

angiotensin-converting enzyme inhibitors and beta-blockers.(44, 45) These data underscore the importance of choosing outcome variables that are most responsive to the study question being addressed.

The 6MWT- can it be a self-administered process and outcome measurement tool?

The data discussed above demonstrates the validity and reliability of the 6MWT and factors influencing the test result. Self-monitoring of functional capacity in CHD has been limited by the use of an empirical tool. High levels of subjectivity affect the description of fatigue and shortness of breath is common in many heart conditions. In diabetes, the use of glucose monitoring and the use of spirometry in people with respiratory conditions have been shown to increase the capacity of individuals to understand and manage their condition.(1) A self-monitoring tool for functional capacity in CHD, has the capacity to monitor physical health status and symptoms over time.

As discussed above, the cardiopulmonary exercise, bicycle and treadmill exercise tests and the shuttle walk are commonly used exercise tests.(20, 46) They are either high-intensity or incremental. Peak oxygen uptake can be monitored during these maximal exercise tests, by using a tight mask for gas analysis. Because of the risk of developing arrhythmias, and acute cardiac events, maximal exercise tests are often contraindicated in populations with severe heart disease.(20, 47) In addition, appropriately trained health professionals are required to administer the test.

These factors limit the usefulness of the maximal exercise test in monitoring functional status over time. In spite of the robust data derived from maximal exercise testing, many patients are reluctant to exercise with the equipment required in the test, particularly

those whose activities of daily living are symptom limited.(5) The use of a submaximal exercise test could meet the needs of people with functional limitations and the needs of older adults, whose functional capacity are limited. However, the submaximal exercise tests and their applications have been less well developed and is an important area for future research.(38) We postulate that the 6MWT could potentially be adapted as a self-administered test for the following reasons,

The 6MWT is a widely acceptable self-paced submaximal exercise test in conditions, such as moderate to severe CHF where maximal exercise testing is contraindicated or where access to equipment is limited. Further, the 6MWT is likely to be less intimidating in older people, particularly women.(38) In people with severe CHF, the 6MWT provides prognostic information on morbidity and mortality, reflecting physical function aspect of HRQoL in measuring impairment. As discussed above, the reliability, validity and responsiveness of the 6MWT have been extensively tested in clinical settings. Gary *et al.*(48, 49) conducted a study examining the use of the 6MWT to evaluate the effectiveness of a 12-week home walk exercise program, in a group of women with diastolic heart failure. Participants were asked to keep a record of the times they walked weekly, as well as their heart rate before, during and after each training session. The rate of adherence to the program protocol in this study was 85% in the participant group. There were also other home-based exercise programs in the literature showing positive effects on patients physical functioning and overall wellbeing. However the effects of these exercise programs are affected by its low program adherence.(38)

Compared to the Home Walk program in the study by Gary *et al.*,(38) the 6MWT

protocol is simpler to follow. Potentially, the 6MWT has the advantage and the potential to be a self-administered measurement tool. This approach will allow a two-pronged approach. Firstly, as a therapeutic intervention to improve functional activity and secondly provide utility as a therapeutic index. (50) Strategies that promote the individual in engaging and monitoring their own clinical condition can potentially improve health outcomes.

Significance and Implications

An important focus of CHD management is monitoring physical functional capacity and promoting self-management. Frequently, people with CHD often need to make modifications to their lifestyle to cope and adjust to their chronic condition.(51) Effective self-management has been shown to give individuals a sense of control over their life in the context of their chronic condition, therefore promoting healthy lifestyle and emotional stability. (52, 53)

The 6MWT is a simple, inexpensive test, not dependent on technological requirements. Based upon the observations reported above, the 6MWT appears promising to investigate as a self-administered tool. (50). Physical assessment is a critical consideration in many chronic conditions. Therefore, a self-directed approach, focussing on self-management and physical activity, will likely improve people's capacity to better monitor their conditions and provide their clinicians with empirical data to inform their management decisions. For example, if such an intervention is demonstrated to be successful, this could easily be incorporated in cardiac rehabilitation and other chronic disease management programs. Through implementing a self-administered 6MWT into a nurse-led disease management program, there is also the potential to improve clinical

outcomes through early recognition of changes in activity that may alert both the patient and clinician to exacerbations. Within the context of the growing burden of CHD, this potential approach is timely as it extrapolates an inexpensive, valid and reliable assessment tool, with strong predictive power, to self-management by the individual in a community based setting.

Conclusion

Maximal exercise testing has been the gold standard for assessing functional capacity, though it has its limitations. The 6MWT can provide valid and reliable information of individual's physical functional capacity. The 6MWT is potentially more representative of the individual's daily activity, compared with maximal exercise testing methods. As a self-administered assessment tool to promote physical activity and self-management strategies, the 6MWT may be useful in improving the community-based management of CHD. Therefore, further studies evaluating the acceptability and utility of the 6MWT and its protocol as a self-administered tool are required.

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