Six-Minute Walk Test (6MWT)

Measurement of Ambulatory Endurance in Adults

Teresa M. Steffen, PhD, PT Research Professor in Rueckert-Hartman College for Health Professions, Regis University, 3333 Regis Boulevard, G-4, Denver, CO 80221-1009 tsteffen@regis.edu 414 213 4280 Reid Nelson, PhD Associate Professor, Concordia University Wisconsin reid.nelson@cuw.edu

Abstract:

Ambulatory endurance is important for older adults interested in participating in life situations, particularly in the community. This paper reviews distance requirements for community ambulation and three measures for quantifying ambulatory endurance. The measurement properties of the six-minute walk test are described.

Seventy-five percent of individuals in inpatient rehabilitation find community ambulation to be essential or very important to them.[1] Ambulatory endurance is a prerequisite to such ambulation. Measures such as the widely used Functional Independent Measure (FIM), which describes "independent ambulation" as walking a minimum of 46 meters without help or a device, do not capture endurance.[2] If problems of ambulatory endurance are to be identified and goals to be established, ambulatory distances required in the community must be considered. Andrews et al, recently described mean distance (standard deviation) requirements needed if individuals are to manage in the community: post office = 52 (23) meters (m), bank = 57 (21) m, medical = 66 (32) m, pharmacy = 206 (27) m, department store = 346 (69) m, grocery store = 380 (86) m, hardware store = 566 (39) m, superstore = 607 (101) m and club warehouse = 677 (159) m.[3] The authors stated that these distances have not changed significantly since Lerner-Frankiel et al published their study reporting mean distances for some similar community locations.[4] The distance walked during the performance of one instrumental activity of daily living task such as shopping or visiting a healthcare practitioner has been described as 304 m for 17 subjects with disabilities (average age 83) and 367 m for 19 without disabilities (average age 78).[5, 6] Brown et al, in a survey of older adults, identified a mean minimum distance for community ambulation to most locations as just less than 200 m; the mean maximum distance was less than 600 m.[7] Exceptions to these minimum and maximum distances were for hospital visits and for trips to shopping malls and superstores. These results were similar to, but more conservative than those of Cohen et al, who determined the maximum distance an elderly individual needed to be able to walk to be considered "functional in the community" was 360 m.[6] They, however, noted that most subjects had two destinations per trip, making 720 m a requirement for community ambulation.

Though the actual testing of ambulatory endurance in the community setting is not practical for clinicians working with older adults, there are established tests that can inform as to ambulatory endurance.

Background

The 6MWT was developed by Balke in1963 as a physical performance measure of functional capacity.[8] The test was modified from the 12 minute walk test originally developed by Cooper and measures the maximum distance a person can walk in six minutes over a flat surface.[9] The test has since gained clinical acceptance due to its ease of set up, administration, patient

tolerance, reproducibility and similarity to requirements of patient function and participation. The 6MWT has been used for morbidity and mortality prognosis in clients with left ventricular dysfunction,[10] chronic obstructive pulmonary disease (COPD),[11, 12] heart failure (HF),[13, 14] primary pulmonary hypertension (PPH)[15, 16] and to guide assessment for transplant.[17, 18] It is now also used in clients with cerebral palsy, stroke, multiple sclerosis, Parkinson disease, orthopedic conditions such as hip and knee surgeries, fibromyalgia, and for people with cancer. The 6MWT is appropriate in clients for whom endurance is a functional issue and improvement in ambulation endurance will reduce participation restrictions.

Contraindications:
The American Thoracic Society (ATS) has identified absolute contraindications to performing the 6MWT as any individual who has unstable angina and/or has had a myocardial infarction during the previous month.[19] Relative contraindications include a resting HR >120 beats per minute, systolic blood pressure >180 mmHg or a diastolic blood pressure >100 mmHg. Although the ATS has listed a myocardial infarction within the last month as an absolute contraindication, another research team tested stable subjects within a week of an uncomplicated myocardial infarction and found the 6MWT to be a safe and reproducible measure of functional capacity.[20]

Test Protocol
The 6MWT is often administered in a hall corridor and could also be done on a treadmill however, treadmill times are often slower.[21-23] Distance achieved should be recorded in meters (m) as most reference data for the test is presented in international units. Ideally, the course should be 30 meters but is often shorter due to shorter hallway distances in many facilities. Turnarounds should be well marked.

Instructions from the American Thoracic Society[19]
The client should sit at rest in a chair located near the starting position for approximately 10 minutes before the test starts. During this time, the pulse and blood pressure should be checked. While standing, the client should rate his/her baseline shortness of breath and fatigue using an appropriate rating scale. The client is told: "The object of this test is to walk as far as possible for 6 minutes. You will walk back and forth in this hallway. Six minutes is a long time to walk, so you may be exerting yourself. You may get out of breath or become tired. You are permitted to slow down, to stop, and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you are able. You will be walking back and forth around the cones. You should pivot briskly around the cones and continue back the other way without hesitation." The therapist should walk with subjects if they need supervision but not get ahead of them. The following feedback is all that should be provided: After the 1st minute: "You are doing well. You have 5 minutes to go" At 2 minutes: "Keep up the good work. You have 4 minutes to go" At 4 minutes: "Keep up the good work. You have only 2 minutes left." At 5 minutes: "You are doing well. You have only 1 minute to go" With 15 seconds remaining in the test: "In a moment I'm going to tell you to stop. When I do, just stop right where you are and I will come to you." At end of test: "Stop!" At completion pulse and blood pressure are measured, post-walk ratings for

shortness of breath, fatigue, and exertion are recorded and the tested individual is asked to answer the question: "What, if anything, kept you from walking farther?"[19(p113-114)]

Factors that can affect six-minute walk test results:
The distance achieved during 6MWT can be affected by a number of different environmental or physiologic variables including: shorter height, age, increased body weight, gender, disease and the extent of disability within a diagnosis along with a shorter walking corridor causing more frequent turns.[24-26] In addition, the number of walk tests previously performed, encouragement during the test, administration of medication before the test and use of supplemental oxygen can all affect test results.[27, 28]
The course layout does have an effect on the distance walked with circular or oval courses tending to allow subjects to walk further[28, 29] although modifying the track from straight to circular had only a small effect change of 13 m.[28] Comparable results between indoor and outdoor conditions were noted in a small study of individuals with COPD when reasonable outdoor climatic conditions were used.[30] Research has shown that second and third trials of the 6MWT tend to be better than the first trial, it is recommended that a practice trial (1or 2) be allowed and record the results of the ensuing trial.[19, 20, 25, 27, 31-33]

Reliability

Test retest reliability: Overall the 6MWT test is very reliable with intraclass correlation coefficients (ICCs) of .87-.99.[20, 29, 30, 33-53] The minimum detectable change $(MDC)_{95,}$ which is relevant to responsiveness, is large because the standard deviations of the people tested are high, meaning variation is large on ambulation endurance. In studies of individuals with neurologic disability, MDCs range from 20 m for people with chronic poliomyelitis[40] to 106 m for people with multiple sclerosis[41] and 86 m for those with Parkinson disease.[47] The MDCs for individuals with cardiac conditions range from 18 to 90 m and in one particularly large study of 786 subjects, an MDC_{95} of 74 to 86 m was noted.[45] A MDC_{95} of 87 m was noted in 470 individuals with lung disease who performed the 6MWT on two successive days.[29] In two separate studies of older adults, the MDC_{95} was shown to range between 77-94 m.[50, 51] Overall an MDC_{95} of 70-90 m would encompass most groups.

Validity

Construct validity: This is the 6MWT's ability to measure functional endurance in ambulation. The "gold standard" for aerobic endurance is peak VO_2. Clinically this "gold standard" is often not available, making the 6MWT a proxy measure of functional capacity. Criterion-related validity indicates that the 6MWT can be used as a substitute for VO_2 primarily in those with HF[54, 55] and COPD.[56] Physical therapists have used the test as a physical performance measure to assess changes in ambulation endurance (reported in the change over time section). Researchers, exercise physiologists, physicians and therapists use the 6MWT similarly but for different purposes. Each group must ask the question does the test measure the construct (functional capacity or functional performance) as intended.

Predictive Validity: Ambulation during the 6MWT of less than 300 m predicted an increased likelihood of death within 6 months of hospital admission in individuals with left ventricular dysfunction (n=898) in 20 hospitals in 3 separate countries.[10] Additional studies have demonstrated that in individuals with HF, a reduced 6MWT distance is predictive of increased mortality in both males (355 m) and females (270 m)[57] and a decrease in retest distance of 100 to 200 m in individuals with chronic heart disease was a prognostic predictor of early mortality.[53, 58, 59] In a smaller study of individuals with PPH, a distance of 300 m or less indicated an increased mortality risk by 2.4.[15] The test is also used as part of an equation to predict outcome in lung transplant clients.[60, 61] In clients with cystic fibrosis awaiting transplant, each 50 m increase in 6MWT distance translated into a 31% reduction in risk of death.[18]
Sensitivity/specificity: Related to predictive validity above, the 6MWT has high sensitivity for the prediction of a clinical event or mortality in several disease conditions. In HF, a 6MWT distance less than 340 m predicted a cardiac event with a sensitivity of 69% and specificity of 48%.[13] A distance of less than 490 m predicted severely reduced peak VO_2 ($\leq$14 $mL \cdot kg^{-1} \cdot min^{-1}$) in the CHF population.[14] Individuals with COPD with a cut off score of greater than 500 m had a sensitivity of survival of 96% while a score of 250 m had a sensitivity of 44% with a specificity of 85%.[12] In a study of individuals with COPD, a 69% sensitivity for mortality was observed based on a cutoff of 350 m.[11] In individuals awaiting lung transplantation, a 6MWT distance less than 400 m showed 80% sensitivity for prediction of death.[17] Predicting death using 6MWTdata may help in health care on initiation or cessation of intervention.

Responsiveness

Although the 6MWT was devised for individuals with cardiopulmonary disease its use has expanded beyond that to clients with neurological and orthopedic conditions. In this section, studies that support change over time of the 6MWT will be reviewed based on diagnostic category. The primary question is whether the 6MWT documents change over time with intervention. Table 1 shows studies identifying change in walking distance following various interventions in several different conditions or disease states. The interesting component of this is that many of these significant changes are smaller than the MDCs outlined above. The test does demonstrate its ability to measure change over time. The change over time has occurred in seniors as well as in many diagnoses such as HF, pulmonary disease, diabetes, neurological diseases and cancer. The change occurred in walking programs, resistance training, circuit training, and hydrotherapy. The 6MWT minimal clinically important difference (MCID) has been estimated at 54-80 m.[62]

Six-Minute Walk Test (6MWT)

Table 1. Intervention effect on 6MWT distance

Disease or Condition	Interventions	Outcomes (meters) *Unless otherwise noted*
Congestive Heart Failure	*Significant increase*	
	Supervised walking[63]	10[63]
	Home walking[64]	36[64]
	Exercise program [65, 66, 67, 68]	84[65] 128[66] 37[67] 62[68]
	Qi gong[69]	114[69]
	Meditation[70, 71]	51[70, 71]
	Water exercise[72]	118[72]
	Interactive session with phone calls[73]	36[73]
	No change	
	Exercise class[74]	
	Web-based intervention [66]	
	Aerobic + resistance[75]	
Chronic Obstructive Pulmonary Disease	*Significant increase*	
	Various Exercise programs [29,76,77,78,79,80]	70[76] 42 & 61[29] 35[77] 46[78,80] 121 to end of program then regressed
	Land & water exercise[81]	land, 42[81] water, 52[81]
	Resistance & endurance training[82]	38-41%[82]
	Walking (rollator assisted)[80]	46[80]
	Long-term oxygen therapy plus home ambulation[83]	18[83]
Diabetes	*Significant increase*	
	Resistance training[84,85]	24[84] 73[85]
	No change	
	Strength, balance, walking exercise (8 visits) [86]	
Post Stroke	*Significant increase*	
	Obstacle course walking[87]	67[87]
	Physical Therapy (18 sessions)[88]	40[88]
	Home-based stretching & resistance training (36 visits)[89]	28[89]
	Circuit-based exercise [90]	41[90]
	Intervention exercise group vs self-initiated	148[91] vs 259[91]

	exercise group followed one year[91] *No change* Home-based exercise with therapist[92]	
Parkinson disease (PD) & Multiple Sclerosis (MS)	*Significant increase* Resistance exercise PD (36 sessions)[93] Resistance exercise MS[94]	119[93] 24[94]
Cancer	*Significant increase* Resistance and Aerobic exercise[95]	80[95] 77[96]
Arthritis, Joint Replacement, Fibromyalgia	*Significant increase* Intensive functional rehabilitation in osteoarthritis post knee arthroplasty[97] Post hip arthroplasty when arm exercise added[98] Osteoarthritis using hydrotherapy[99] Knee osteoarthritis and hydrotherapy[100] Exercise in Fibromyalgia[101,102]	78, 93, 100 dependent on rehab length[97] 405 vs 259 trained vs control[98] 51[99] 12%[100] 27-34[101] 78[102]
Seniors with mobility problems	*Significant increase* Circuit-style exercise (10 sessions)[103] Females in weight reduction program[104] Aerobic training (18 months)[105] Aerobic + resistance training (1 year)[106]	29[103] 22-29[104] 12%[105] 46[106]

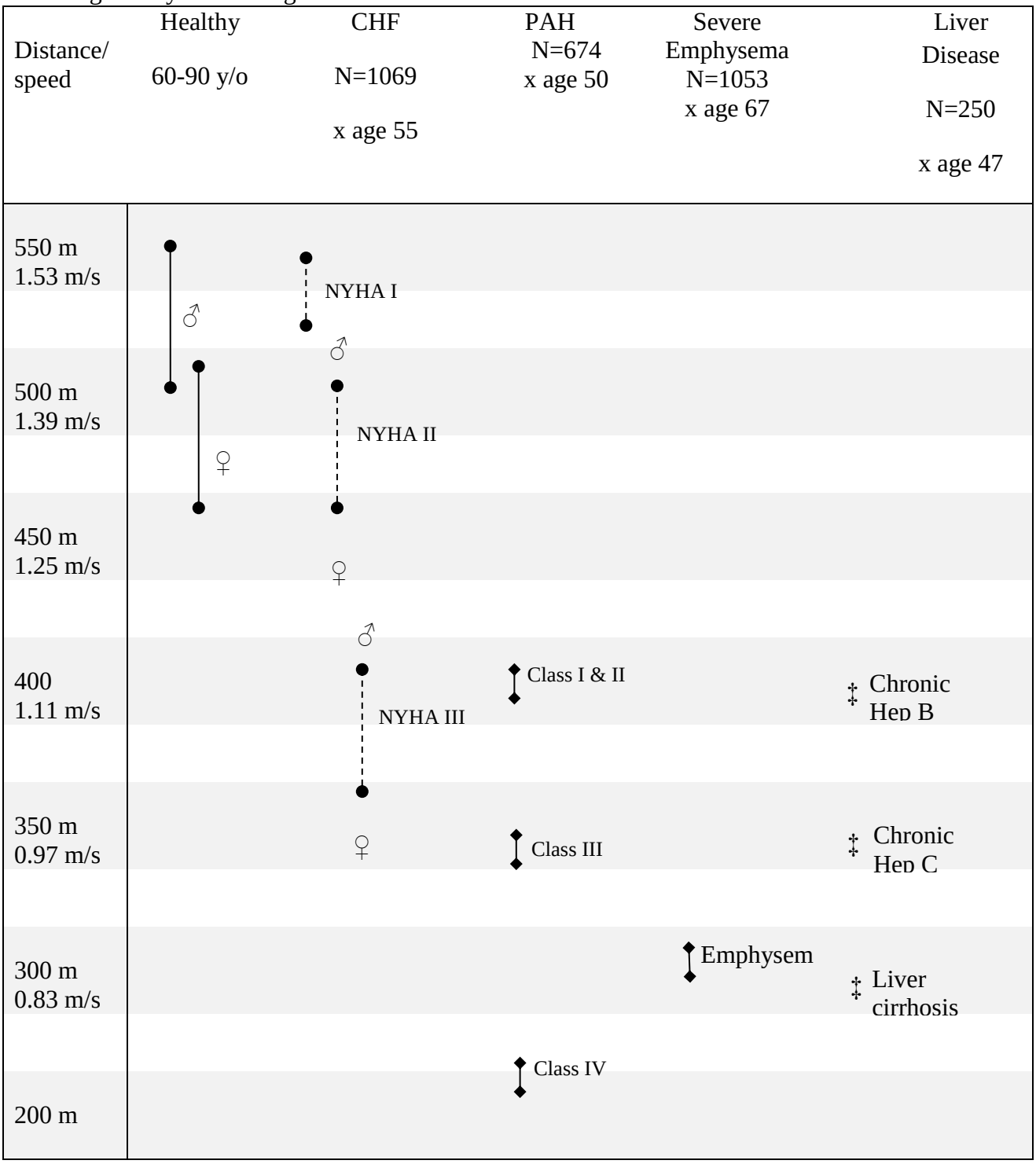
Reference Data

A meta-analysis focused on normal values for seniors (60-90 years old)[107] and involved 13 studies for a pooled sample size of 4809 men and women.[51, 108-119] The meta-analysis reported the normal distance to be 499 (480-519) m with a range from 475 (448-503) m for women and 524 (496-553) m for men. The 6MWT distance decreased as age increased as measured in ten year cohorts through age 89. One study reported 90-94 year old women (n=79) as 326 (115) m and male (n=48) as 368 (135) m.[116]

In 1035 people with New York Heart Association class I-III HF (mean age 55), the mean distance walked for the 6MWT was 466 (113) m for males and 432 (111) m for females.[57] In 674 people (mean age 50) with pulmonary arterial hypertension Class I-II, distance walked was 415 (86) m, Class III 319 (92) m and Class IV 192 (96) m.[120] In 1053 people with severe

Six-Minute Walk Test (6MWT)

emphysema (mean age 67) the 6MWT was 328 (89) m.[121] These are the largest three studies with 6MWT data posted. These scores are lower than the values reported for the community dwelling elderly over the age of 60.



Six-Minute Walk Test (6MWT)

DISCUSSION AND CONCLUSION

The 6MWT test is the most utilized test of ambulation endurance. For a few people it could be a functional capacity test but in most cases it is an endurance test of walking speed. A therapist can use the 6MWT to inform clients of their scores relative to norms for age, gender and distance. The team of client and therapist can establish a plan using the MDC by diagnosis for their goal. Clients can then set up their exercise program with the help of the therapist. Change of score may help to motivate some clients to continue with an exercise program. Overall measuring endurance helps the client and therapist move forward to increased ambulation endurance in the community.

Data collection Form:

HR (bpm)	BP (mm Hg)	Borg (shortness of breath) 0-10	Borg (fatigue) 0-10	Borg (exertion) 6-20
Pre-Test:				
Post-Test:				
What, if anything, kept you from walking farther?				
Distance walked (nearest meter**): _____**meters **# laps:** **additional distance:** **# rests:** **Comments:**				

Borg Scale: Shortness of Breath and Fatigue

0 – nothing at all
0.5 – very, very slight (just noticeable)
1 – very slight
2 – slight (light)
3 – moderate
4 – somewhat severe
5 – severe (heavy)
6 –
7 – very severe
8 –
9 –
10 – very, very severe (maximal)

Borg Scale: Exertion

6 – no exertion at all
7 – extremely light
8 –
9 – very light
10 –
11 – light
12 –
13 – somewhat hard
14 –
15 – hard (heavy)
16 –
17 – very hard
18 –
19 – extremely hard
20 – maximal exertion

Six-Minute Walk Test (6MWT)

1. Lord S, McPherson K, McNaughton H, Rochester L Weatherall M. Community ambulation after stroke: how important and obtainable is it and what measures appear predictive? *Arch Phys Med Rehabil.* 2004;85:234-239.
2. Keith R, Granger C, Hamilton B Sherwin F. The functional independence measure: a new tool for rehabilitation. *Adv Clin Rehabil.* 1987;1 6-18.
3. Andrews A, Chinworth S, Bourassa M, et al. Update on distance and velocity requirements for community ambulation *J Geriatr Phys Ther.* 2010;33:128-134.
4. Lerner-Frankiel MB, Vargas S, Brown MB, Krusell L Schoneberger W. Functional community ambulation: what are your criteria? *Clin Manag Phys Ther.* 1986;6:12-15.
5. Shumway Cook A, Patla A, Stewart A, et al. Environmental demands associated with community mobility in older adults with and without disabilities. *Phys Ther.* 2002;82:670-81.
6. Cohen J, Sveen J, Walker J, Brummel-Smith K Establishing criteria for community ambulation. *Top Geriatr Rehabil.* 1987;3 71-77.
7. Brown C, Bradberry C, Green H, et al. Defininng community ambulation from the perspective of the older adult *J Geriatr Phys Ther* 2010;33:56-63.
8. Balke B. A simple field-test for the assessment of physical fitness. *Rep Civ Aeromed Res Inst US.* 1963;53:1-8.
9. Cooper K. A Means of Assessing Maximal Oxygen Intake Correlation Between Field and Treadmill Testing. *JAMA.* 1968;203:135-138.
10. Bittner V, Weiner DH Yusuf S. Prediction of mortality and morbidity with a 6-minute walk test in patients with left ventricular dysfunction. *JAMA.* 1993;270:1702-1707.
11. Cote C, Pinto-Plata V, Kasprzyk K, Dordelly L Celli B. The 6-min walk distance, peak oxygen uptake, and mortality in COPD. *Chest.* 2007;132:1778-1785.
12. Casanova C, Cote C, Marin J, et al. Distance and oxygen desaturation during the 6-min walk test as predictors of long-term mortality in patients with COPD. *Chest.* 2008;134:746-752.
13. Lee R, Chan Y, Wong J, Lau D Ng K. The 6-minute walk test predicts clinical outcome in Asian patients with chronic congestive heart failure on contemporary medical therapy: A study of the multiracial population in Singapore. *Int J Cardiol.* 2007;119:168-175.
14. Pulz C, Diniz R, Alves A, et al. Incremental shuttle and six-minute walking tests in the assessment of functional capacity in chronic heart failure. *Can J Cardiol.* 2008;24:131-135.
15. Paciocco G, Martinez FJ, Bossone E, et al. Oxygen desaturation on the six-minute walk test and mortality in untreated primary pulmonary hypertension. *Eur Respir J.* 2001;17:647-652.
16. Miyamoto S, Nagaya N, Satoh T, et al. Clinical correlates and prognostic signficance of six-minute walk test in patients with primary pulmonary hypertension. *Am J Respir Crit Care Med.* 2000;161:487-492.
17. Kadikar A, Maurer J Kesten S. The six-minute walk test: A guide to assessment for lung transplantation. *J Heart Lung Transplant.* 1997;16:313-319.
18. Vizza C, Yusen R, Lynch J, et al. Outcome of patients with cystic fibrosis awaiting lung transplantation. *Am J Respir Crit Care Med.* 2000;162:819-825.
19. Society AT. ATS statement: guidelines for the six-minute walk test. *Amer J Resp Crit Care Med.* 2002;166:111-117.
20. Nogueira P, Leal A, Pulz C, Nogueira I Filho J. Clinical reliability of the 6 minute corridor walk test performed within a week of a myocardial infarction. *Int Heart J.* 2006;47:533-540.
21. Greig C, Skelton D, Mahmud S Young A. Treadmill walking in old age may not reproduce the real life situation. *J Am Geriatr Soc.* 1993;41:15-18.

22. Swerts P, Mostert R Wouters E. Comparison of corridor and treadmill walking in patients with severe chronic obstructive pulmonary disease. *Phys Ther.* 1990;70:439-442.
23. Stevens D, Elpern E, Sharma K, et al. Comparison of hallway and treadmill six-minute walk tests. *Am J Respir Crit Care Med.* 1999;160:1540-1543.
24. Guyatt GH, Sullivan MJ, Thompson PJ, et al. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. *Can Med Assoc J.* 1984;132:919-923.
25. Enright P, McBurnie M, Bittner V, et al. The 6-min walk test: a quick measure of functional status in elderly adults. *Chest.* 2003;123:387-398.
26. Ingle L, Rigby AS, Nabb S, et al. Clinical determinants of poor six-minute walk test performance in patients with left ventricular systolic dysfunction and no major structural heart disease. *Eur J Heart Fail.* 2005;8:321-325.
27. Spencer L, Alison J McKeough Z. Six-minute walk test as an outcome measure. *Am J of Phys Med and Rehabil.* 2008;87:224-228.
28. Bansal V, Hill K, Dolmage T, et al. Modifying track layout from straight to circular has a modest effect on the 6-minute walk distance. *Chest.* 2008;133:1155-1160.
29. Sciurba F, Criner G, Lee S, et al. Six-minute walk distance in chronic obstructive pulmonary disease. *Am J of Resp Crit Care Med.* 2003;167:1522-1527.
30. Brooks D, Solway S, Weinacht K, Wang D Thomas S. Comparison between an indoor and an outdoor 6-minute walk test among individuals with chronic obstructive pulmonary disease. *Arch Phys Med Rehabil.* 2003;84:873-876.
31. Siler W, Koch N Frese E. The path utilized affects the distance walked in the 12 minute walk test. *Cardiopulm Phys Ther.* 1999;10:80-83.
32. Milligan NP, Havey J Dossa A. Using a 6-minute walk test to predict outcomes in patients with left ventricular dysfunction. *Rehabil Nurs.* 1997;22:177-181.
33. Montgomery PSGardner AW. The clinical utility of a six-minute walk test in peripheral arterial occlusive disease patients. *J Am Geriatr Soc.* 1998;46:706-711.
34. Eng J, Dawson A Chu K. Submaximal exercise in persons with stroke: test-retest reliability and concurrent validity with maximal oxygen consumption. *Arch Phys Med Rehabil.* 2004;85:113-118.
35. Fulk G, Echternach J, Nof L O'Sullivan S. Clinometric properties of the six-minute walk test in individuals undergoing rehabilitation poststroke. *Physiother Theory Pract.* 2008;24:195-204.
36. Flansbjer U, Holmback A, Downham D, Patten C Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. *J Rehabil Med.* 2005;37:75-82.
37. Mossberg K. Reliability of a timed walk test in persons with acquired brain injury. *Am J Phys Med Rehabil.* 2003;82:385-392.
38. Andersson C, Asztalos L Mattsson E. Six-minute walk test in adults with cerebral palsy. A study of reliability. *Clin Rehabil.* 2006;20:488-495.
39. Thompson P, Beath T, Bell J, et al. Test-retest reliability of the 10-metre fast walk test and 6-minute walk test in ambulatory school-aged children with cerebral palsy. *Dev Med Child Neurol.* 2008;50:370-376.
40. Gylfadottir S, Dallimore M Dean E. The relation between walking capacity and clinical correlates in survivors of chronic spinal poliomyelitis. *Arch Phys Med Rehab.* 2006;87:944-952.
41. Fry DPfalzer L. Reliability of four functional tests and rating of perceived exertion in persons with multiple sclerosis. *Physiother Can.* 2006;58:212-219.
42. Van Loo M, Moseley A, Bosman J, De Bie R Hassett L. Test-re-test reliability of walking speed, step length and step width measurement after traumatic brain injury: a pilot study. *Brain Inj.* 2004;18:1041-1048.

43. Hamilton DHaennel R. Validity and reliability of the 6-minute walk test in a cardiac rehabilitation population. *J Cardiopulmonary Rehabil.* 2000;20:156-164.
44. Guyatt GH, Thompson PJ, Berman LB, et al. How should we measure function in patients with chronic heart and lung disease? *J Chron Dis.* 1985;38:517-524.
45. Demers C, McKelvie R, Negassa A Yusuf S. Reliability, validity, and responsiveness of the six-minute walk test in patients with heart failure. *Am Heart J.* 2001;142:698-703.
46. Buch M, Denton C, Furst D, et al. Submaximal exercise testing in the assessment of interstitial lung disease secondary to systemic sclerosis: reproducibility and correlations of the 6-min walk test. *Ann Rheum Dis.* 2007;66:169-173.
47. Steffen TSeney M. Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short form health survey, and the unified Parkinson disease rating scale in people with Parkinsonism. *Phys Ther.* 2008;88:733-746.
48. Ries J, Echternach J, Nof L Blodgett M. Test-retest reliability and minimal detectable change scores for the timed up & go test, the six-minute walk test, and gait speed in people with alzheimer disease. *Phys Ther.* 2009;89:569-579.
49. Mandrusiak A, Maurer C, MacDonald J, Wilson C Watter P. Functional capacity tests in young people with cystic fibrosis. *NZ Journal of Physiotherapy.* 2009;37:13-16.
50. King M, Judge J, Whipple R Wolfson L. Reliability and responsiveness of two physical performance measures examined in the context of a functional training intervention. *Phys Ther.* 2000;80:8-16.
51. Harada ND, Chiu V Stewart AL. Mobility-related function in older adults: Assessment with a 6-minute walk test. *Arch Phys Med Rehabil.* 1999;80:837-841.
52. Mangione K, Craik R, McCormick A, et al. Detectable changes in physical performance measures in elderly African Americans. *Phys Ther.* 2010;90:921-927.
53. Ingle L, Wilkinkson M, Carroll S, et al. Cardiorespiratory requirements of the 6-min walk test in older patients with left ventricular systolic dysfunction and no major structural heart disease. *Int J Sports Med.* 2007;28:1-7.
54. Cahalin LP, Mathier MA, Semigran MJ, Dec GW DiSalvo TG. The six-minute walk test predicts peak oxygen uptake and survival in patients with advanced heart failure. *Chest.* 1996;110:325-332.
55. Faggiano P, D'Aloia A, Gualeni A, Lavatelli A Giordano A. Assessment of oxygen uptake during the 6-minute walking test in patients with heart failure: Preliminary experience with a portable device. *Am Heart J.* 1997;134:203-206.
56. Cahalin L, Pappagianopoulos P, Prevost S, Wain J Ginns L. The relationship of the 6-minute walk test to maximal oxygen consumption in transplant candidates with end-stage lung disease. *Chest.* 1995;108:452-459.
57. Frankenstein L, Remppis A, Graham J, et al. Gender and age related predictive value of walk test in heart failure: do anthropometrics matter in clinical practice? *Int J Cardiol.* 2008;127:331-336.
58. Passantino A, Lagioia R, Mastropasqua F Scrutinio D. Short-term change in distance walked in 6 min is an indicator of outcome in patients with chronic heart failure in clinical practice. *JACC.* 2006;48:99-105.
59. Eurich D, Johnson J, Reid K Spertus J. Assessing responsiveness of generic and specific health related quality of life measures in heart failure. *Health Qual Life Outcomes.* 2006;4:89-89.
60. Cardoso F, Tufanin A, Colucci M, Nascimento O Jardim J. Replacement of the 6-min walk test with maximal oxygen consumption in the BODE index applied to patients with COPD. *Chest.* 2007;132:477-482.
61. Chetta A, Zanini A, Pisi G, et al. Reference values for the 6-min walk test in healthy subjects 20-50 years old. *Respir Med.* 2006;100:1573-1578.

62. Wise RBrown C. Minimal clinically important differences in the six-minute walk test and the incremental shuttle walking test. *COPD: J Chronic Obstructive Pulmonary Disease.* 2005;2:125-129.
63. Kavanagh T, Myers MG, Baigrie RS, et al. Quality of life and cardiorespiratory function in chronic heart failure: Effects of 12 months' aerobic training. *Heart.* 1996;76:42-49.
64. Corvera-Tindel T, Doering L, Woo M, Khan S Dracup K. Effects of a home walking exercise program on functional status and symptoms in heart failure. *Am Heart J.* 2004;147:339-346.
65. Freimark D, Shechter M, Schwamenthal E, et al. Improved exercise tolerance and cardiac function in severe chronic heart failure patients undergoing a supervised exercise program. *Int J Cardiol.* 2007;116:309-314.
66. Artinian N, Harden J, Kronenberg M, et al. Pilot study of a web-based compliance monitoring device for patients with congestive heart failure. *Heart Lung.* 2003;32:226-233.
67. Jonsdottir S, Andersen K, Sigurosson A Sigurosson S. The effect of physical training in chronic heart failure. *Europ J Heart Fail.* 2006;8:97-101.
68. Wright DJ, Khan KM, Gossage EM Saltissi S. Assessment of a low-intensity cardiac rehabilitation programme using the six-minute walk test. *Clin Rehabil.* 2001;15:119-124.
69. Pippa L, Manzoli L, Corti I, et al. Functional capacity after traditional Chinese medicine (Qi Gong) training in patients with chronic atrial fibrillation: A randomized controlled trial. *Prev Cardiol.* 2007;10:22-25.
70. Jayadevappa R, Johnson JC, Bloom BS, et al. Effectiveness of transcendental meditation on functional capacity and quality of life of African Americans with congestive heart failure: A randomized control study. *Ethn Dis.* 2007;17:72-77.
71. Sayers S, Brach J, Newman A, et al. Use of self report to predict ability to walk 400 meters in mobility-limited older adults. *J Am Geriatr Soc.* 2004;52:2099-2103.
72. Municino A, Nicolino A, Milanese M, et al. Hydrotherapy in advanced heart failure: the Cardio-HKT pilot study. *Monaldi Arch Chest Dis.* 2006;66:247-254.
73. Ramachandran K, Husain N, Maikuri R, et al. Impact of a comprehensive telephone-based disease management programme on quality-of-life in patients with heart failure. *Natl Med J India.* 2007;20:67-73.
74. Van Laethem C, Van De Veire N, De Backer G, et al. Response of the oxygen uptake efficiency slope to exercise training in patients with chronic heart failure. *Europ J Heart Fail.* 2007;9:625-629.
75. Dracup K, Evangelista L, Hamilton M, et al. Effects of a home-based exercise program on clinical outcomes in heart failure. *Am Heart J.* 2007;154:877-883.
76. Stewart D, Drake D, Robertson C, et al. Benefits of an inpatient pulmonary rehabilitation program: A prospective analysis. *Arch Phys Med Rehabil.* 2001;82:347-352.
77. Holland A, Hill C, Conron M, Munro P McDonald C. Short tem improvement in exercise capacity and symptoms following exercise training in interstitial lung disease. *Thorax.* 2008;63:549-554.
78. Nishiyama O, Kondoh Y, Kimura T, et al. Effects of pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis. *Respirology.* 2008;13:394-399.
79. Karapolat H, Atasever A, Atamaz F, et al. Do the benefits gained using a short-term pulmonary rehabilitation program remain in COPD patients after participation? *Lung.* 2007;185:221-225.
80. Probst V, Troosters T, Coosemans I, et al. Mechanisms of improvement in exercise capacity using a rollator in patients with COPD. *Chest.* 2004;126:1102-1107.
81. Lotshaw A, Thompson M, Sadowsky H, Hart M Millard M. Quality of life and physical performance in land- and water-based pulmonary rehabilitation. *J Cardiopulm Rehabil Prev.* 2007;27:247-251.

82. Spruit M, R G, Troosters T, De Paepe K Decramer M. Resistance versus endurance training in patients with COPD and peripheral muscle weakness. *Eur Respir J.* 2002;19:1072-1078.
83. Faager GLarsen F. Performance changes for patients with chronic obstructive pulmonary disease on long-term oxygen therapy after physiotherapy. *J Rehabil Med.* 2004;36:153-158.
84. Headley S, Germain M, Maillous P, et al. Resistance training improves strength and functional measures in patients with end-state renal disease. *Am J Kidney Dis.* 2002;40:355-364.
85. Parsons T, Toffelmire E King-Van Vlack C. Exercise training during hemodialysis improves dialysis efficacy and physical performance. *Arch Phys Med Rehabil.* 2006;87:680-687.
86. LeMaster J, Mueller M, Reiber G, et al. Effect of weight-bearing activity on foot ulcer incidence in people with diabetic peripheral neuropahty: feet first randomized controlled trial. *Phys Ther.* 2008;88:1385-1398.
87. Bassile C, Dean C, Boden-Albala B Sacco R. Obstacle training programme for individuals post stroke: feasibility study. *Clin Rehabil.* 2003;17:130-136.
88. Salbach N, Mayo N, Wood-Dauphinee S, et al. A task-oriented intervention enhances walking distance and speed in the first year post stroke: a randomized controlled trial. *Clin Rehabil.* 2004;18:509-519.
89. Duncan P, Studenski S, Richard L, et al. Randomized clinical trial of therapeutic exercise in subacute stroke. *Stroke.* 2003;34:2173-2180.
90. Yang Y, Wang R, Lin K, Chu M Chan R. Task-oriented progressive resistance strength training improves muscle strength and functional performance in individuals with stroke. *Clin Rehabil.* 2006;20:860-870.
91. Langhammer B, Stanghelle J Lindmark B. An evaluatoin of two different exercise regimes during the first year following stroke: a randomised controlled trial. *Physiotherapy Theory and Practice.* 2009;25:55-68.
92. Duncan P, Richards L, Wallace D, et al. A randomized controlled pilot study of a home-based exercise program for individuals with mild and moderate stroke. *Srtoke.* 1998;29:2055-2060.
93. Dibble LLange M. Predicting falls in individuals with Parkinson disease: a reconsideration of clinical balance measures
J Neurol Phys Ther. 2006;30:60-67.
94. Rampello A, Franceschini M, Piepoli M, et al. Effect of aerobic training on walking capacity and maximal exercise tolerance in patients with multiple sclerosis: a randomized crossover controlled study. *Phys Ther.* 2007;87:545-555.
95. Hanna L, Avila P, Meteer J, Nicholas D Kaminsky L. The effects of a comprehensive exercise program on physical function, fatigue, and mood in patients with various types of cancer. *Oncol Nurs Forum.* 2008;35:461-469
96. Morris G, Gallagher G, Baxter M, et al. Pulmonary rehabilitation improves functional status in oncology patients. *Arch Phys Med Rehabil.* 2009;90:837-841.
97. Moffet H, Collet J, Shapiro S, et al. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty: a single-blind randomized controlled trial. *Arch Phys Med Rehabil.* 2004;85:546-556.
98. Maire J, Fiallenet-Maire A, Grange C, et al. A specific arm-interval exercise program could improve the health status and walking ability of elderly patients after total hip arthroplasty: a pilot study. *J Rehabil Med.* 2004;36:92-94.
99. Gowans S, DeHueck A Voss S. Six-minute walk test: A potential outcome measure for hydrotherapy. *Arthritis Care Res.* 1999;12:208-211.
100. An B, Dai K, Zhu Z, et al. Baduanjin alleviates the symptoms of knee osteoarthritis. *J of Alternative and Complimentary Medicine.* 2008;14:167-174.

101. Rooks D, Gautam S, Romeling M, et al. Group exercise, education, and combination self-management in women with fibromyalgia. *Arch Intern Med.* 2007;167:2192-2200.
102. Pankoff B, Overend T, Lucy D White K. Validity and responsiveness of the 6 minute walk test for people with fibromyalgia. *J Rheumatol.* 2000;27:2666-2670.
103. Sherrington C, Pamphlett P, Jacka J, et al. Group exercise can improve participants' mobility in an outpatient rehabilitation setting: a randomized controlled trial. *Clin Rehabil.* 2008;22:493-502.
104. Lemoine S, Rossell N, Drapeau V, et al. Effect of weight reduction on quality of life and eating behaviors in obese women. *Menopause.* 2007;14:432-440.
105. Mangani I, Cesari M, Kritchevsky SB, et al. Physical exercise and comorbidity. Result from the fitness and arthritis in seniors trial (FAST). *Aging Clin Exp Res.* 2005;18:374-380.
106. Deley G, Kervio G, Van Hoecke J, et al. Effects of a one-year exercise training prgram in adults over 70 years old: a study with a control group. *Aging Clin Exp Res.* 2007;19:310-315.
107. Bohannon R. Six-minute walk test: A meta-analysis of data from apparently healthy elders. *Topics in Geriatr Rehab.* 2007;23:155-160.
108. Bautmans I, Lambert M Mets T. The six-minute walk test in community dwelling elderly: influence of health status. *BMC Geriatr.* 2004):4-6.
109. Cress M, Petrella J, Moore T Schenkman M. Continuous-Scale Physical Functional Performance Test: validity, reliability, and sensitivity of data for the short version. *Phys Ther.* 2005;85:323-335.
110. Gibbons WJ, Fruchter N, Sloan S Levy RD. Reference values for a multiple repetition 6-minute walk test in healthy adults older than 20 years. *J Cardiopulm Rehabil.* 2001;21:87-93.
111. Kalapotharakos V, Michalopoulos M, Tokmakidis S, et al. Effects of a resistance exercise programme on the performance of inactive older adults. *Int J Ther Rehabil.* 2004;11:318-323.
112. Kervio G, Carre F Ville N. Reliability and intensity of the six-minute walk test in healthy elderly subjects. *Med Sci Sports Exerc.* 2003;35:169-174.
113. Lusardi M, Pellechia G Schulman M. Functional performance in community living older adults. *J Geriatr Phys Ther.* 2003;26:14-22.
114. Peel CBallard D. Reproducibility of the 6-minute walk test in older women. *J Aging Phys Activ.* 2001;9:184-193.
115. Peterson M, Crowley G, Sullivan R Morey M. Physical function in sedentary and exercising older veterans as compared to national norms. *J Rehabil Res Dev.* 2004;41:653-658.
116. Rikli RJones C. Functional fitness normative scores for community-residing older adults, ages 60-94. *J Aging Phys Activity.* 1999;7:162-181.
117. Steffen T, Hacker T Mollinger L. Age-and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and Gait Speeds. *Phys Ther.* 2002;82:128-137.
118. Troosters T, Gosselkink R Decramer M. Six minute walking distance in healthy elderly subjects. *Eur Respir J.* 1999;14:270-274.
119. Enright PLSherrill DL. Reference equations for the six-minute walk in healthly adults. *Am J Resp Critic Care Med.* 1998;158:1384-1387.
120. Humbert M, Sitbon O, Chaouat A, et al. Pulmonary arterial hypertension in France. *Am J Respir Crit Care Med.* 2006;173:1023-1030.
121. Martinez F, Curtis J, Sclurba F, et al. Sex differences in severe pulmonary emphysema. *Am J Respir Crit Care Med.* 2007;176:243-252.