Title: Reference values for standardized tests of walking speed and distance: A systematic review

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Abstract

Objective: To provide an overview of the reference values and methodology used to obtain them for time- and distance-limited walk tests.

Methods: We performed a systematic review and searched PubMed, MEDLINE (Ovid), EMBASE, CINAHL, Scopus, PEDro, and *The Cochrane Library* from 1946 to May 2013. Full-text peer-reviewed articles written in English, French or Spanish were considered eligible. Two authors independently screened titles and abstracts. One author determined eligibility of full-text articles, appraised methodological quality, and extracted data. A second author independently verified the accuracy of extracted data.

Results: Of the 41 eligible studies reviewed, 25 failed to describe the method used to select participants and 10 had an inadequate sample size. Twenty-five studies provided reference values for one time-limited walk test (6-min walk test (6 MWT)) and 18 studies provided reference values for 15 distance-limited walk tests. Across studies, walk test distances ranged from 3m to 40m. Descriptive values and reference equations for the 6 MWT were reported in 15 and 20 studies, respectively. Across 43 regression equations (median $R^2=0.46$), age (98%) and sex (91%) were most frequently included. The equation yielding the maximum R^2 value (0.78) included age, height, weight and percentage of predicted maximum heart rate. Among six unique regression equations for distance-limited walk tests (median $R^2=0.17$), sex (83%), age (67%) and weight (67%) were most frequently included. The equation yielding the maximum R^2 value (0.25) included age and sex.

Conclusions: Reference values reported for these tests provide a basis for classifying walking capacity as within normal limits, determining the magnitude of deficit, educating clients, setting rehabilitation goals, and planning studies.

Key words (up to 5 MeSH terms): walking, reference values, review, rehabilitation

3-5 Research Highlights:

1. We reviewed the literature on reference values for tests of walking distance and speed.
2. Reference values for the 6-min walk test from 18 countries were available.
3. Reference values for 15 tests of walking speed from 8 countries were available.
4. Age and sex were most frequently used to describe or predict reference values.

INTRODUCTION

Numerous chronic diseases, including stroke, arthritis, and chronic obstructive pulmonary disease (COPD), can result in a diminished capacity to walk and referral to rehabilitation services.¹⁻³ Evaluation and monitoring of limited walking capacity requires the use of standardized assessment tools. Time- and distance-limited tests of walking capacity have the advantages of being quick, simple tests, which can be administered with minimal training and equipment in research and clinical settings.^{4, 5} Time-limited tests, such as the two-, six- and twelve-minute walk tests⁶ (2 MWT, 6 MWT, and 12 MWT, respectively), are self-paced exercise tests that measure the maximum distance a person can walk in the time of the test. Distance-limited tests, such as the 5- and 10-meter walk tests (5 mWT and 10 mWT, respectively), are used to measure walking speed.⁷

Time- and distance-limited walk tests have been widely used in randomized controlled trials to measure the effects of therapeutic interventions⁸⁻¹⁰ owing to the excellent reliability and sensitivity to change of performance scores across diagnostic groups.¹¹⁻¹⁷ Performance on these tests can be used to determine an individual's capacity for community ambulation to complete essential activities such as crossing the street in the time of a walk signal or walking the distance required to complete grocery shopping.^{18, 19} Others^{20, 21} have demonstrated that walking speed and distance are health indicators that predict mortality in older adults.

Despite the importance of walking distance and speed, clinical use of time- and distance-limited walk tests is sub-optimal.²² An estimated 32% to 44% of physical therapists report using tests of walking speed, and between 11% and 44% report using tests of walking distance.²³⁻²⁵

A primary barrier to the use of standardized assessment tools is a lack of perceived clinical relevance of performance scores²⁶ and insufficient confidence about how to interpret the

scores.²⁴ To address these barriers, evidence of the interpretability of scores on time- and distance-limited walk tests is needed. Interpretability refers to *the degree to which one can assign qualitative meaning - that is, clinical or commonly understood connotations – to an instrument's quantitative scores or change in scores,*²⁷ such as through comparison with 'normative' or 'reference values'.²⁸ Reference values have commonly involved generating either age- and sex-specific mean or median performance scores^{29, 30} or regression equations for deriving values^{29, 31} based on data from healthy individuals. Clinicians can use reference values to determine whether walking capacity is within normal limits, judge the magnitude of the walking deficit, educate the patient, family and members of the healthcare team about the severity of the walking deficit, and set realistic goals for rehabilitation. Researchers make use of reference values to express participant performance as a percentage of what healthy individuals can achieve.^{32, 33}

There are numerous studies reporting reference values for time- and distance-limited walk tests, making it difficult for time-pressed clinicians to select the most appropriate study. To our knowledge, however, a comprehensive and methodologically rigorous systematic review of the research literature describing reference values for time- and distance-limited walk tests has not been published. A systematic review of normal walking speed published in 2011³⁴ included a meta-analysis of values for age- and sex-specific categories. The review was restricted to describing walking speed at a normal pace. Providing benchmarks for fast walking speed is particularly important for understanding capacity to walk more quickly in response to environmental demands in the community, such as the light changing to yellow when crossing the street. Although regression equations for deriving reference values for walking speed based on not only age, and sex but also height are available,^{29, 35} these were not included. Pooling data in a meta-

analysis masks the modifying influence of height³⁶ and weight,³⁶ which correlate with walking speed in healthy individuals,³⁶ and the potential influence of test distance, and country.^{37, 38}

Finally, the review lacked a critical appraisal of the included studies which is a quality criteria for the conduct of systematic reviews.³⁹ Thus, the objectives of the current study were to provide an overview of reference values and regression equations for time- and distance-limited walk tests and of the methodology used to obtain them. The ultimate goal of this research is to increase the interpretability and use of time- and distance-limited walk tests in clinical and research practice and to provide a basis for planning future studies.

METHODS

Overview

We conducted a systematic review according to a review protocol guided by the PRISMA statement.³⁹

Search Strategy

We searched seven electronic databases (MEDLINE (Ovid), EMBASE, PubMed, CINAHL, Scopus, PEDro, and *The Cochrane Library*) from 1946 to May 2013. Search strategies were developed for each database with input from the research team and an information specialist. A combination of the following search terms was used: reference value, normative data, gait speed and a wide variety of terms associated with walk tests (see Appendix 1 for the PubMed search strategy). No limitations were applied during the search. We also reviewed the principal investigator's library, reference lists of included studies and surveyed the research team. We imported all titles and abstracts into a reference management database for the removal of duplicated citations. Subsequently, citations were uploaded to DistillerSR™ (<http://systematic-review.net>), a centralized online application that we used to complete study selection, quality appraisal and data extraction.

Selection Criteria

Studies were considered eligible if: (1) the aim of the study was to establish reference values and/or reference equations for a time- and/or distance-limited walk test; (2) distance-limited walk tests included an acceleration and deceleration distance so that walking speed would reflect that achieved at a steady state; (3) descriptive data were presented in numerical format to enable accurate reporting; (4) the pace of walking and distance walked were identified so the test could be replicated; (5) participants included adults 18 years and older; and (6) the article was written

in English, French or Spanish. We excluded studies in which: (1) participants had musculoskeletal, neurological, cardiovascular or respiratory disease limiting walking ability; (2) the study population was limited to obese participants; (3) participants required an ambulatory device and/or human assistance to walk; (4) the walk test was completed on a treadmill; (5) distance-limited tests involved a turn; or (6) the study was a conference proceeding, dissertation, case report/series or limited to abstract form.

Study Selection

The research team developed a guide to conducting data extraction and critical appraisal and pilot tested electronic forms to perform eligibility screening, data extraction and critical appraisal. Two reviewers independently screened titles and abstracts and classified studies as potentially relevant or not relevant to the review. A single author (N.M.S. or P.T.) independently determined the eligibility of potentially relevant studies. A third author (E.I.) was consulted to resolve uncertainty regarding the eligibility of a study.

Data Extraction

A single reviewer (N.M.S. or P.T.) independently extracted the following data from studies included in the review: general study information, study characteristics, participant characteristics, walk test protocol, statistical approach, and results. A second reviewer, who was fluent in one of the three languages (English, French or Spanish), verified the original data extracted and data converted for analysis purposes. Discrepancies were resolved through discussion.

Method of Quality Assessment

The methodological quality of included studies was assessed using a modified 4- and 5-item version of the Interpretability and Generalizability checklists, respectively, of the CONsensus-

based Standards for the selection of health Measurements INstruments (COSMIN) critical appraisal tool.⁴⁰ Checklist items not relevant to studies establishing reference values were removed.

The response options for all items were “yes/no” except for a single item on the Interpretability checklist with a third response option of “can’t tell”. Response options of yes, no and can’t tell were assigned a score of 1, 0 and 0.5, respectively and an overall score for the two checklists combined expressed as a percentage was derived. As recommended by COSMIN developers,⁴⁰ the team developed operational definitions for select COSMIN items to optimize consistency of scoring. For item 1 on the interpretability checklist, an “adequate” sample size was defined as ≥ 15 in each age- and/or sex-specific category for reporting of descriptive reference values, and as ≥ 50 for reference equations. To respond “Yes” to items 3 or 5 on the Generalisability checklist, the setting in which participants were recruited (item 3) and the method used to select participants (item 7) had to be explicitly stated within the article. The country in which the study was conducted could be derived from the text of the article or the authors’ affiliations. A single reviewer (N.M.S. or P.T.) assessed the methodological quality of included studies. A third reviewer (E.I.) was consulted to resolve uncertainty.

Data Synthesis and Analysis

To provide an overview of the methodology used to develop reference values across studies, we described the method of sampling, type of descriptive statistic, approach to regression modeling, and walk test protocols, in addition to reporting COSMIN scores. We also examined the level of obesity and physical activity (active vs. sedentary), smoking status, and lung function among participants to evaluate the extent to which they were healthy. Body mass index (BMI) values were interpreted as: 18.5-24.9 (normal); 25.0-29.9 (overweight); 30.0-34.99 (obese class I),⁴¹ and

forced expiratory volume in one second (FEV₁) values above 80% predicted were considered as normal.⁴²

To provide an overview of reference values, we presented descriptive reference values and/or regression equations according to the objectives of included studies. The median distance and speed walked by men and women in each age decade was computed. Within and across studies, we presented mean descriptive reference values by age decade and country in men and women for studies with a minimum sample size of 15 in each sex- and age-specific category. Between-category differences of $\geq 50\text{m}$ for the 6 MWT and $\geq 0.15\text{m/s}$ were noted.⁴³ To provide an overview of the reference equations, we determined the frequency at which each independent variable was included across equations and computed the median and range of R^2 values.

To ease comparison across studies, results were converted to a common metric unit. For example, distance and speed values were presented in meters (m) and meters per second (m/s), respectively. Walk test performance scores and reference values were rounded to the first decimal place for distance and to the second decimal place for speed, and R^2 values were rounded to two decimal places for clarity of presentation.

Results

Study Selection

Figure 1 illustrates the source of articles and the article selection process. A total of 41 studies met the eligibility criteria and were included in our systematic review. Of the 41 included studies, 32 studies were located from bibliographic databases, and 9 studies from other sources (e.g., reference lists of included studies). Of the 20 authors contacted to obtain information pertaining to the methods or results, 12 (60%) authors provided the requested information.

Study Characteristics

Of the 41 included studies, articles were written in English^{29-31, 36-38, 44-75} (n=38), Spanish^{76, 77} (n=2) or French⁷⁸ (n=1). Twenty-five studies established reference values for a time-limited walk test; the 6 MWT was the sole walk test examined. The 6 MWT was examined in 18 countries. Of the 25 studies, 15 reported descriptive data and 20 reported 43 unique regression equations for computing 6 MWT reference values. Eighteen studies provided reference values for 15 unique distance-limited tests defined by distance and timing technology (supplementary Table 1S). Of the 18 studies, 18 reported descriptive data and four reported six unique regression equations. Distance-limited walk tests were examined in eight countries.

Appraisal of Study Methodology

Figure 2 and 3 present the item-level COSMIN scores for the Interpretability and Generalisability checklists for each included study examining time- and distance-limited walk tests, respectively. Total quality scores for studies examining time- and distance-limited walk tests ranged from 44% to 89% and 56% to 89%, respectively. Among studies of time-limited walk tests, the three most common methodological issues, apart from variable “important flaws” identified in each study, were failure to describe the method used to select participants (48%), inadequate sample size (24%), and failure to report scores and change scores for relevant subgroups (12%). Among studies of distance-limited walk tests, the three methodological issues most frequently observed apart from variable “important flaws” were failure to report the method used to select participants (72%) and the setting in which the study was conducted (33%), and inadequate sample size (22%).

Among 30 studies with sampling information, participants were either a convenience sample⁷⁰ (87%) or randomly selected from a population (13%). Across studies providing descriptive results, reference values were summarized using the mean in 30 studies^{29, 30, 36-38, 45-59, 62-64, 66, 69-72,}

^{74, 77} and the median in one study.⁴⁴ Multiple and simple linear regression were used to develop reference equations in 23 studies and one study, respectively. The method to determine the final model was automated stepwise model selection in 12 studies,^{31, 37, 38, 59, 60, 64-67, 70, 74, 75} variable methods in five studies^{36, 62, 68, 69, 73} (e.g., pre-selected variables, variables yielding the highest R^2 , etc.) and were not reported in six studies.^{29, 47, 61, 76-78} Authors reported verification of assumptions of linear regression in four studies,^{31, 67, 69, 73} testing for multicollinearity in four studies,^{31, 67, 70, 75} and validation of the model in a separate sample of participants in five studies.^{61, 66, 67, 73, 75} None of the studies reported the residual standard deviation of the final regression model.

Health Status of Participants

In 29 studies reporting BMI, there were underweight, overweight and/or obese participants in one, 29 and 18 studies, respectively. Only studies targeting the 6 MWT reported physical activity, smoking status and FEV among participants. In 17 studies reporting physical activity level, samples consisted of variable proportions of people classified as sedentary or active. In six^{37, 38, 60-62, 74} out of 15 studies that provided information on smoking status, the percentage of current smokers ranged from 18% to 46%. In 12 studies reporting FEV₁, we were able to classify lung function as normal based on either the range⁵⁹ (n=1), mean^{37, 60-62, 64-66, 70, 73-75} (n=11) or the median⁶⁸ (n=1).

Time-limited Walk Test Protocol

Walkway Shape, Length and Location

In 24 of the 25 studies (96%) evaluating the 6 MWT, the test was performed along a straight walkway ranging from 15m to 82.3m in length. The two most common distances were 30m (48%) and 45m (12%). In one study, a rectangular walkway measuring 6m long and 4m wide

was used.⁵⁵ In 18 studies, the 6 MWT was performed indoors along a corridor/hallway^{31, 38, 49, 59-70, 74} (n=16), an indoor track³⁰ (n=1), or within a research laboratory⁷⁶ (n=1). The 6 MWT was completed outdoors in one study⁷⁷ and either indoors or outdoors in one study.⁷² Test location was not reported in five studies.^{37, 55, 73, 75, 78} Participants were tested individually except for one study⁷² in which groups of 3 to 6 people completed the walk test together. The 6 MWT protocols used in studies reporting descriptive reference values and reference equations are described in Tables 1 and supplementary Table 2S, respectively.

Pre-Test Instructions

Seventeen studies (68%) described instructions provided to participants on how to prepare for the test. In seven studies,^{37, 63-65, 69, 76, 78} instructions followed the ATS statement.¹⁴ In eight studies, participants were asked to avoid caffeine,^{30, 31, 38, 59, 74} alcohol,^{30, 31, 38, 59, 72, 74} and tobacco products³⁰ either two,^{38, 59, 74} four,³¹ six³⁰ or 24⁷² hours prior to testing. Participants were also instructed to avoid the consumption of a heavy meal^{38, 59, 74} or any type of meal^{30, 31, 70} either two^{31, 38, 59, 70, 74} or six³⁰ hours prior to testing and to avoid strenuous physical exercise on the day of the study,³¹ two⁶⁷ or 24 hours^{30, 38, 59, 70, 72, 74} prior to the walk test. Additional instructions reported in select studies were to eat a light morning meal,^{66, 72} wear comfortable clothing and shoes^{66, 67, 72} and engage in 8-10 minutes of general warm-up and stretching exercises prior to the testing session.⁷² In one study,⁵⁵ investigators provided participants with sports sandals to minimize risk of injury and the effect of footwear on test performance.

Test Instructions, Encouragement and Position of Test Administrator

Slightly more than half of the included studies (60%, 15/25) implemented the test instructions to participants outlined in the ATS guideline for administering the 6MWT.^{30, 31, 37, 38, 63-65, 67, 69, 70, 73-}

^{76, 78} An additional ten studies instructed participants to walk as quickly or as far as possible^{55, 59-62, 72} (n=6), at their own pace^{49, 66, 68} (n=3) or at a slow pace⁷⁷ (n=1).

Encouragement was provided during the 6 MWT in 22 of 25 studies (88%). Thirteen studies^{30, 31, 37, 38, 63-65, 69, 70, 73, 75, 76, 78} adhered to the ATS guideline for providing encouragement. The remaining nine studies provided standardized encouragement, four^{59, 60, 62, 66} of which provided standardized encouragement as described in the study conducted by Guyatt et al.⁷⁹ Where reported, walk test administrators remained positioned at either the starting line^{31, 37, 61-63, 65} (n=6), or at the mid-point mark along the walkway^{38, 59, 66} (n=3), or they walked alongside⁵⁵ (n=1) or behind⁶⁰ the participant (n=1). In a single study, the administrator walked with the participant during the initial lap to ensure the accuracy of the return point and then remained standing beside the walkway for the remainder of the walk test.³⁰

Descriptive Reference Values for the 6 MWT

Table 1 presents study, walk test protocol, and participant characteristics and norms for the 15 studies reporting descriptive reference values. Age- and/or sex-specific reference data were reported in 14 studies^{30, 38, 49, 55, 59, 62-64, 66, 69, 70, 72, 74, 77} conducted in 10 countries (Australia, Brazil, Canada, Hong Kong, India, Mexico, Saudi Arabia, Singapore, Thailand and USA) and one study³⁷ reported values for 10 cities in seven countries (Brazil, Chile, Columbia, Spain, USA, Uruguay and Venezuela). Across five studies,^{49, 55, 63, 72, 77} the median 6 MWT distance for each age decade in men (M) and women (W) was: 20-30 years: M-621m, W-576m; 30-40 years: M-606m, W-562m; 40-50 years: M-603m, W-541m; 50-60 years: M-578m, W-534m; 60-70 years: M-491m, W-440m; 70-79 years: M-400m, W-350m.

Variation by Country

Casanova et al.³⁷ compared 6 MWT performance using a standardized protocol in men and women aged 40-80 years across 10 cities in seven countries. On average, participants from Caracas, Venezuela walked a distance (510m) that was significantly shorter than that performed by people from Tenerife, Bogota, Sao Paulo, and Montevideo. Participants from Sao Paulo, Brazil covered a distance (638m) that was significantly greater than the distance performed by participants from Zaragoza, Caracas, Santiago de Chile, Tampa and Boston. Within the USA, there was no significant difference between the mean distance walked by participants from Tampa (535m) and Boston (557m).

Descriptive reference values for sex-specific age decades across four countries were compared (supplementary Figures 1S and 2S). In the 60-69 to ≥ 80 year decades, male and female participants from the USA walked, on average, more than 150m further (range 153-201m) than men and women from Thailand.⁵⁵ Across countries, there was variability in walk test distance and shape, and participant height.

Reference Equations for the 6 MWT

Table 3 lists the 43 unique reference equations for the 6 MWT reported in 20 studies conducted in 16 countries. Of the 43 equations, 13 were developed in men, 13 were developed in women and 17 were developed in men and women combined. Nine distinct independent variables were modelled. The four variables most frequently included across the 43 reference equations were age (98%), sex (91%), height (70%) and weight (49%). The R^2 values ranged from 0.04 to 0.78 (median 0.46). The equation yielding the largest R^2 value (0.78) included age, height, weight, and %predHR_{max}.

Distance-limited Walk Test Protocol

Walkway Length, Timing Technology and Pace

Table 2 presents the walk test protocol described in the 18 included studies for 15 unique distance-limited walk tests classified according to test walkway length, walk pace and technology used. The test distance (excluding acceleration and deceleration distances) for walk tests timed using a stopwatch^{29, 44, 47, 48, 58} (n=5) ranged from 3 to 10m. Test distance for walk tests timed using other methods, including instrumented mats^{49-52, 80} (n=5), camera systems^{54, 56, 71} (n=3), clinical stride analyser⁵³ (n=1), accelerometry⁴⁵ (n=1) and infrared reflecting system and force plates³⁶ (n=1), ranged from 3 to 40m. Acceleration and/or deceleration distances reported in 78% of studies ranged from 0.9 to 6.0m (median 3.3m), with four studies failing to specify the distances used.⁴⁵⁻⁴⁸ Distance-limited walk tests were performed at a comfortable/self-selected/normal/free pace^{29, 36, 44-56, 58, 71, 80} (n=18), maximum/fast pace^{46-49, 51, 55, 80} (n= 7), and slow pace^{46, 80} (n= 2).

Descriptive Reference Values for Distance-limited Walk Tests

Table 2 presents study and participant characteristics and the age- and/or sex-specific descriptive reference values reported in the 18 included studies. Across studies providing descriptive results by age decade, the median self-selected walking speed per decade in men and women was: 20-30 years: M-1.39m/s, W-1.34m/s;^{36, 46, 48, 53} 30-40 years: M-1.46m/s, W-1.36m/s;^{36, 46, 48, 53} 40-50 years: M-1.41m/s, W-1.38m/s;^{29, 36, 46, 48, 53} 50-60 years: M-1.37m/s, W-1.27m/s;^{29, 36, 46, 48, 53} 60-70 years: M-1.27m/s, W-1.24m/s;^{29, 36, 46, 48, 49, 53, 55} 70-79 years: M-1.18m/s, W-1.13m/s.^{29, 36, 46, 48-53, 55}

Variation by Country

Descriptive reference values for comfortable walking speed for sex-specific age decades from four countries were compared (supplementary Figures 3S and 4S). Differences between countries were noted for select age decades. Men from The Netherlands³⁶ walked faster, on average, by at

least 0.15m/s than men from Sweden,⁴⁶ Thailand⁵⁵ and the USA.⁵⁰⁻⁵² American men walked faster, on average, than men from Sweden and Thailand.⁵⁵ Women from The Netherlands³⁶ walked faster, on average, than women from Australia,⁵³ Sweden,⁴⁶ Thailand,⁵⁵ and the USA.⁷² Australian women⁵³ walked faster than Swedish women.⁴⁶ American women⁷² walked faster than women from Sweden,⁴⁶ Australia,⁵³ and Thailand.⁵⁵

Within the USA, men and women from Connecticut⁴⁸ walked faster than men and women from Minneapolis⁵² and New York.⁵⁰ Men from Connecticut⁵¹ walked faster than men from the state of New York.⁵⁰

Across these studies, walk test protocols varied with respect to test distance (range 3.0-7.6m), acceleration/deceleration distances (range 0.9-4.3m) and technology used (GaitRite mat,⁵⁰⁻⁵² stopwatch,^{46, 48, 55} an infrared reflecting system,³⁶ and a clinical stride analyser⁵³).

Reference Equations for Distance-limited Walk Tests

Table 3 presents six unique reference equations for distance-limited walk tests from four studies conducted in Brazil,²⁹ Japan,⁵⁴ The Netherlands³⁶ and USA.⁴⁷ Equations compute reference values for either comfortable (n=5) or fast (n=1) walking speed. The three most common independent variables were sex (83%), age (67%), and weight (67%) and the R^2 value ranged from 0.09-0.25 (median $R^2=0.17$). The equation yielding the maximum R^2 value (0.25) included age and sex.

DISCUSSION

Tests Examined and Protocol Elements

In almost every study, the 6 MWT was performed along a straight walkway that, in approximately half of the protocols, measured 30m. The ATS protocol¹⁴ was most consistently applied in the delivery of pre-test and test instructions and encouragement suggesting that this

protocol is useful and could serve as a standard for subsequent studies. When described, evaluators most often remained at the starting line or the mid-point mark along the walkway during the 6 MWT in adherence with the ATS guideline.¹⁴ When people with balance impairment perform the 6 MWT, however, test administrators should walk near the participant to safeguard against falls.

The literature on 6 MWT reference values has widespread applicability as this test is commonly used for clinical and research purposes in cardiopulmonary, orthopedic and neurological rehabilitation.¹⁰⁻¹² Clinically, physical therapists providing stroke rehabilitation report implementing the 2 MWT more frequently than the 6- and 12 MWT²³ suggesting that reference values for the 2 MWT may be useful.

Although reference values are available for only one time-limited walk test, they have been reported for as many as 15 unique distance-limited tests in eight countries. One-third of tests described were feasible for clinical implementation as they required minimal equipment, timing using a stopwatch and a manual calculation of walking speed. One-third of tests were conducted on an instrumented walkway such as a GaitRite mat that uses electronic signals and computer software to generate walking speed and other temporal-distance gait parameters. GaitRite mats are widely used in research to investigate balance and gait. Although the high cost of this method may prohibit widespread clinical adoption, researchers and clinicians collaborating in a university-affiliated rehabilitation hospital have recently demonstrated how evaluation using the GaitRite mat can be incorporated into routine clinical evaluation for people with stroke.⁸¹ The use of an acceleration and deceleration distance to ensure measurement of walking speed at a steady state (median distance was 3.3m) is standard practice given only 8 studies were excluded for not describing this test feature. People in all included studies were instructed to walk at a

comfortable or self-selected pace; slow pace, however, was seldom examined. Availability of reference values of maximum speed, observed in seven studies, enables interpretation of an individual's capacity to accelerate, provides an upper benchmark for goal setting, and potentially predicts recovery.

Factors Influencing Walking Distance and Speed

Substantial investigation has aimed to identify variables that accurately predict 6 MWT reference values using regression techniques. A number of factors are important to consider when taking this statistical approach. First, the feasibility and appropriateness of measuring a given independent variable in the clinical setting should be considered to optimize uptake of the regression equation. For example, age and sex, variables that were most frequently included in reference equations for the 6 MWT, are quickly determined through self-report and observation. Models including only age and sex explained an appreciable proportion of variability in 6 MWT reference values (30% in Brazilians,⁶¹ and 41%⁶² and 49%³¹ in Canadians). Other independent variables, such as height, weight, BMI, %predHR_{max} and FEV₁, require additional testing, specialized equipment, trained personnel, calculations and, thus, additional time which may limit the uptake of regression equations that include these variables. Finally, use of %predHR_{max} to predict 6 MWT reference values should be avoided as HR response during the 6 MWT in many clinical populations may be blunted due to beta blocker medication prescribed for cardiovascular disease.³¹

Second, multicollinearity should be considered when selecting variables for regression models. Multicollinearity refers to the occurrence of two or more independent variables in a multiple regression model that are highly related to one another such that one can be linearly predicted from the others.⁸² In five reference equations across included studies, height and BMI were

included in the same model. This can lead to multicollinearity because height is used to compute BMI and is expected to highly correlate with BMI.⁴¹ Multicollinearity does not influence how well the group of independent variables predicts the outcome variable (the reference value in this case). Instead, multicollinearity affects the interpretation of individual regression coefficients as it inflates the values of their standard errors potentially rendering them non-significant.⁸² A variance inflation factor value of >10 is considered an indicator of multicollinearity.⁸² Although evaluating multicollinearity is recommended, it was reported in less than 25% of studies presenting regression equations. Another dramatically underreported statistic from regression models is the residual standard deviation. The residual standard deviation is the standard deviation of the differences between observed values and corresponding values predicted by the regression equation and, thus, indicates the precision with which the regression line predicts reference values.

To optimize consideration of feasibility and appropriateness of variables when finalizing regression models, investigators should reconsider using an automated stepwise regression approach that was applied in half of the studies to derive a final reference equation for the 6 MWT. A more appropriate approach would be to identify variables significantly associated with 6 MWT performance and determine which of these variables should be included in the final model based on the strength of the relationship, and the ease and appropriateness of measurement in targeted clinical populations. Verification of the assumptions of linear regression, the absence of multicollinearity and the residual standard deviation of the final model should be reported. Although validation of the final regression model in a separate population is advisable,⁸³ this was performed in only 20% of studies describing reference equations. Our review findings suggest variability in 6 MWT reference values across countries.

Investigators have demonstrated that regression equations developed in a different country yield significantly different 6 MWT values than those observed in their own country.³⁸ These results would indicate that other factors, such as culture, motivation, and effort, may explain the differences in 6 MWT performance observed in healthy individuals across countries. Results underscore the value in developing region-specific reference values.

Compared to walking distance, few studies have aimed to develop regression equations to compute reference values for walking speed. The regression equations for walking speed explain a much lower proportion of variability in values than equations for the 6 MWT (median R^2 value 0.17 vs. 0.46, respectively). Age and sex explain 25% of the variability in walking speed over 10m and between 30% and 49% of the variability in 6 MWT distance. Thus, although it is common to report descriptive reference values for walking speed by age and sex, these findings indicate the need to identify variables other than those examined to date that can be modelled to produce accurate reference values for walking speed.

Additional Methodological Issues

Less than half of the 15 studies reporting descriptive reference values for the 6 MWT reported distances by age category which is a known correlate. In contrast, reporting walking speed by age category is more typical and was done in 72% of studies. Descriptive values for both time- and distance-limited walk tests have been most frequently reported in participants with a mean age of 50 years and older. Values for these age groups are particularly needed given the high incidence of chronic disabling diseases in older age. The sample sizes in the oldest age categories, however, were consistently the lowest likely due to difficulty with recruitment. This decreases the precision of the reference values estimated for the oldest age categories and, when

the sample size fell below 15, resulted in rating the study as having inadequate sample size using the COSMIN Interpretability checklist.

Additional methodological issues relate to eligibility criteria and sampling. The extent to which participants across studies were “healthy” could be criticized given the large proportion of studies that included individuals classified as either overweight or obese and as smokers.

Although smoking and obesity are risk factors for chronic disease,⁸⁴ they are not proxies for ill health and thus should not be used to operationally define health. Inclusion of people classified as overweight may be justified given these individuals make up a notable proportion of the general population.^{85, 86} Convenience sampling of volunteers was the approach consistently taken across studies included in this review. Convenience samples may be less representative of the general population than samples obtained by random selection.^{87, 88} The influence of sampling method on the accuracy of the reference values obtained, however, has not been examined.

Clinical Implications

Results highlight a number of considerations when selecting a set of descriptive reference values or a regression equation to use for comparison with patient performance. First, the age, sex, and country or culture of the participants in which the reference study was conducted should be the same as or similar to the clinical population. The reference study should ideally have a minimum of 15 people per sex- and age-decade so that the reference values are sufficiently precise. When selecting a regression equation, the variables in the equation must be easily and accurately measured in the clinical population to facilitate a quick calculation of the reference value. The regression equations will only yield appropriate reference values for people whose age falls within the range of ages of the participants studied to develop the regression equation. Finally, the walk test protocol and number of trials used to generate the reference values should be

adopted and feasible to implement in your setting. For example, if reference values or equations were developed based on the maximum 6 MWT distance achieved in three trials, and you do not have sufficient time to administer three tests, then choose a set of reference values based on one or two trials. Healthy individuals tend to walk significantly further in the second trial of the 6 MWT than the first trial.^{31, 37, 59, 60} Thus, reference values based on the maximum performance across multiple trials will be higher than those based on the first trial and may yield inflated benchmarks that may be too ambitious to achieve. When implementing a test of walking speed, the same walk test protocol, including the test distance, acceleration and deceleration distances, the walk pace and instructions, used in the study that generated the reference values may be more important to replicate than the technology used to time the test.

If both descriptive reference values and a regression equation from high quality studies are available and use the same test protocol, the decision to use one or the other can be guided by ease of use and precision. Descriptive values are readily accessible as they can be physically posted or provided electronically in a table to enable quick reference. Regression equations require a computation and thus more time to generate the reference value. Smartphone applications or web-based calculators could be designed to enable quick computation of reference values derived from regression equations. If the sample size for each age- and sex-specific category is substantially larger in the study that produced descriptive values than in the study that produced the regression equation, then the precision of the descriptive values is likely superior.

The distance or speed of walking achieved by a patient can be expressed as a percentage of the reference value to indicate the magnitude of deficit, or compared to the 95% CI or the range of reference values to determine if the patient's performance is below or within normal limits.

These interpretations can then be communicated to the patient, the family, and to members of the health care team to increase understanding of the impact of clinical conditions on walking capacity and to help set goals. Re-administration of the test over time will enable the patient and healthcare team to gauge recovery.

Limitations of the Review

The use of a single individual to determine eligibility and complete data extraction and quality appraisal is a limitation of the review methodology. However, the procedures and forms used for these steps were piloted in collaboration with the lead investigator and a second individual verified all data extracted to optimize accuracy. This review was limited to literature with a stated objective of producing reference values. Although other studies may provide data on healthy individuals, we reasoned that the quality of these data would not be as high, methodology not as rigorous, and the study samples not as representative compared to studies designed to obtain reference values.

Conclusions

There is an extensive body of literature providing descriptive reference values and reference equations for the 6 MWT but not other time-limited walk tests. Numerous studies provide descriptive reference values but few provide reference equations for distance-limited walk tests. Published regression equations explain a greater proportion of the variability in performance on time- than on distance-limited walk tests. Methodological considerations for future research aimed at generating reference values are provided.

Conflict of interest statement: Authors have no conflicts of interest to disclose.

Appendix 1. PubMed Search Strategy

Reference values [MeSH]

OR

(Reference value* OR reference range* OR normative research OR normative standard* OR normative data OR normative score* OR normal range*[Text Word]

AND

6 minute walk test OR six minute walk test OR 6MWT OR 6 minute walk test* OR six minute walk test*[text word]

OR

6 minute walk test OR six minute walk test OR 6MWT OR 6 minute walk test* OR six minute walk test*[MeSH]

OR

6-minute walk test OR 6-minute walk test* OR 6-min walk test* OR 6MWD OR six-minute walk test* OR six-min walk test*[Text Word]

OR

6-minute walk test OR 6-minute walk test* OR 6-min walk test* OR 6MWD OR six-minute walk test* OR six-min walk test*[MeSH]

OR

2 minute walk test OR two minute walk test OR 2MWT OR 2 minute walk test* OR two minute walk test*[Text Word]

OR

2 minute walk test OR two minute walk test OR 2MWT OR 2 minute walk test* OR two minute walk test*[MeSH])

OR

2-minute walk test OR 2-minute walk test* OR 2-min walk test* OR 2MWD OR two-minute walk test* OR two-min walk test*[Text Word]

OR

2-minute walk test OR 2-minute walk test* OR 2-min walk test* OR 2MWD OR two-minute walk test* OR two-min walk test*[MeSH]

OR

12 minute walk test OR twelve minute walk test OR 12MWT OR 12 minute walk test* OR twelve minute walk test*[Text Word]

OR

12 minute walk test OR twelve minute walk test OR 12MWT OR 12 minute walk test* OR twelve minute walk test*[MeSH]

OR

12-minute walk test OR 12-minute walk test* OR 12-min walk test* OR 12MWD OR twelve-minute walk test* OR twelve-min walk test*[Text Word]

OR

12-minute walk test OR 12-minute walk test* OR 12-min walk test* OR 12MWD OR twelve-minute walk test* OR twelve-min walk test*[MeSH]

OR

5 meter walk test OR five meter walk test OR 5mWT OR 5 meter walk test* OR five meter walk test*[Text Word]

OR

5 meter walk test OR five meter walk test OR 5mWT OR 5 meter walk test* OR five meter walk test*[MeSH]

OR

5 metre walk test OR five metre walk test OR 5mWT OR 5 metre walk test* OR five metre walk test*[Text Word]

OR

5 metre walk test OR five metre walk test OR 5mWT OR 5 metre walk test* OR five metre walk test*[MeSH]

OR

10 meter walk test OR ten meter walk test OR 10mWT OR 10 meter walk test* OR ten meter walk test*[Text Word]

OR

10 meter walk test OR ten meter walk test OR 10mWT OR 10 meter walk test* OR ten meter walk test*[MeSH]

OR

10 metre walk test OR ten metre walk test OR 10mWT OR 10 metre walk test* OR ten metre walk test*[Text Word]

OR

10 metre walk test OR ten metre walk test OR 10mWT OR 10 metre walk test* OR ten metre walk test*[MeSH]

OR

3-minute walk test OR 3-minute walk test* OR 3-min walk test* OR three-minute walk test* OR three-min walk test*[Text Word]

OR

3-minute walk test OR 3-minute walk test* OR 3-min walk test* OR three-minute walk test* OR three-min walk test*[MeSH]

OR

3 minute walk test OR 3 minute walk test* OR 3 min walk test* OR three minute walk test* OR three min walk test*[Text Word]

OR

3 minute walk test OR 3 minute walk test* OR 3 min walk test* OR three minute walk test* OR three min walk test*[MeSH]

OR

5-minute walk test OR 5-minute walk test* OR 5-min walk test* OR five-minute walk test* OR 5-min walk test*[Text Word]

OR

5-minute walk test OR 5-minute walk test* OR 5-min walk test* OR five-minute walk test* OR 5-min walk test*[MeSH]

OR

5 minute walk test OR 5 minute walk test* OR 5 min walk test* OR five minute walk test* OR 5 min walk test*[Text Word]

OR

5 minute walk test OR 5 minute walk test* OR 5 min walk test* OR five minute walk test* OR 5 min walk test*[MeSH]

OR

walk test OR walk tests OR walk test*[Text Word]) OR (walk test OR walk tests OR walk test*[MeSH]

OR

functional walk test OR functional walk tests OR functional walk test* OR function* AND walk test OR function* AND walk tests OR function* AND walk test*[Text Word]

OR

functional walk test OR functional walk tests OR functional walk test* OR function* **AND** walk test OR function* **AND** walk tests OR function* AND walk test*[MeSH]

OR

time limited walk test* OR time-limited walk test* OR time-limited walk test OR time limited walk tests OR time limited walk test OR time-limited walk tests OR time-limited walk test[Text Word]

OR

time-limited walk test OR time limited walk tests OR time limited walk test OR time-limited walk tests OR time limited walk test* OR time-limited walk test*[MeSH]

OR

self paced functional walk test OR self paced functional walk tests OR self paced functional walk test* OR self paced function* AND walk test OR self paced function* AND walk tests OR self paced function* AND walk test* OR self-paced functional walk test OR self-paced functional walk tests OR self-paced functional walk test* OR self-paced function* AND walk test OR self-paced function* AND walk tests OR self-paced function* AND walk test*[Text Word]

OR

self paced gait speed OR self-paced gait speed[Text Word]

OR

self paced gait speed OR self-paced gait speed[MeSH]

OR

Gait[MeSH]

OR

Gait[Text Word]

OR

functional walk* AND capacity OR Function* AND walk* AND capacity[Text Word]

OR

Gait speed[Text Word]

OR

walk* AND speed[Text Word]

Table 1. Study, walk test protocol and participant characteristics and results for studies reporting descriptive reference values for the 6-min walk test (n=15)

First author, Year	Country, Sampling Method	Walk Test Protocol			Participants				Results
		Path Distance, Shape, Pace	No. Trials, Rest Time, Scoring	Encouragement, Interval	BMI (kg/m ²) Mean±SD and/or Range	Sex	Age (years) Mean±SD and/or Range	n	Distance (m) Mean±SD (Range)
Camarri, 2006 ⁵⁹	Australia, Random	45m, Straight, Walk as quickly as you can	3 trials, 20 min, Maximum distance	Yes, 1 min	P: 26±4	M	NR	33	690±53
						W	NR	37	631±57
						P	65±5 (55-75) 55-65 65-75	70	659±62 (484-820)
								36 34	
Jenkins, 2009 ⁷⁴	Australia, NR	45m, Straight, Walk as quickly as you can	2 trials, ≥20 min and HR within 10 beats of the resting value, Maximum distance	Yes, 1 min	M: 26±4	M	64±8	48	682±73 (549-900)
					W: 25±4	W	61±9	61	643±70 (478-816)
Soares, 2011 ⁶⁹	Brazil, Convenience	30m, Straight, ATS*	3 trials, HR within 10 beats of the resting value, Maximum distance	ATS [†]	M: 18-24: 29% 25-29: 42% 30-38: 27%	M	20-29	9	566±87
							30-39	10	
					W: 18-24: 42% 25-29: 33% 30-38: 24%	W	40-49	10	538±95
							50-59	12	
Steffens, 2013 ⁷⁰	Brazil, Convenience All subjects	30m, Straight, Walk as quickly as possible	2 trials, ≥30 min, Maximum distance	ATS [†]	NR	W	66±7	77	502±67
					W: 26±3	W	66±6	46	520±64
					W: 26±3	W	67±6	31	476±64

Gibbons, 2001 ⁶²	Canada, Convenience	20m Straight, Walk as quickly as you can	4 trials, 30 min, Maximum distance	Yes, 30 sec	P: 24±3	M	20-40	19	800±83
							41-60	12	671±56
							61-80	10	687±89
						W	20-40	15	699±37
							41-60	13	670±85
61-80	10	583±53							
Tsang, 2005 ⁶³	Hong Kong, Convenience	15m, Straight, ATS*	1 trial, N/A, N/A	ATS [†]	P: 22±3 (17-39)	M	21-30	80	651±105 (340-840)
							31-40	78	645±93 (330-900)
							41-50	38	623±80 (465-795)
							51-60	23	588±68 (500-705)
							61-70	4	484±90 (370-566)
						W	21-30	85	600±84 (347-825)
							31-40	108	606±86 (365-905)
							41-50	79	541±67 (333-769)
							51-60	33	534±89 (380-765)
							61-70	14	432±54 (350-554)
Vaish, 2013 ⁶⁴	India (North), Convenience	30m Straight, Own pace	1 trial, N/A, N/A	ATS [†]	M: 25±3	M	40-60	101	536±47
Padron, 2000 ⁷⁷	Mexico, NR	25m, Straight, Slow pace	1 trial, N/A, N/A	NR	M: 26 (21-31) [‡] W: 25 (21-29) [‡]	M	20-29	27	471 (379) [§]
							30-39	24	485 (395) [§]
							40-49	15	486 (375) [§]
							50-59	9	493 (448) [§]
							60-69	6	476 (370) [§]
						W	20-29	48	474 (375) [§]
							30-39	27	459 (300) [§]
							40-49	24	451 (330) [§]
							50-59	13	459 (405) [§]
							60-69	7	447 (335) [§]
		M	20-29	27		621 (544) [§]			
			30-39	24		606 (524) [§]			
			40-49	15		603 (500) [§]			
			50-59	9		578 (500) [§]			
			60-69	6		585 (475) [§]			
		W	20-29	48		576 (502) [§]			
			30-39	27		562 (440) [§]			
			40-49	24		553 (369) [§]			
			50-59	13		545 (450) [§]			
		25m, Straight, Fast pace	1 trial, N/A, N/A	NR					

							60-69	7	546 (475) ^s
Alameri, 2009 ⁶⁶	Saudi Arabia, Random	30m, Straight, Own pace	1 trial, N/A, N/A	Yes, 1 min	M: 26±4 W: 26±5	M	28±8	127	430±48
						W	30±8	111	386±46
Poh, 2006 ³⁸	Singapore, Convenience	45m, Straight, ATS*	3 trials, NR, Maximum distance	ATS [†]	P: 24±4	M	NR	16	586±126 (450-796)
						W	NR	19	538±82 (405-650)
Suwanach-aly, 2010 ³⁰	Thailand, Convenience	30m, Straight, ATS*	3 trials, 20 min and return to resting HR, Maximum distance	ATS [†]		All	NR	162	635±75 (489-994)
	Sufficient Activity				M: 24±2	M	53±6	37	702±89
					W: 23±3	W	54±6	45	620±49
					M: 24±2	M	54±5	40	653±56
					W: 23±2	W	55±5	4	573±36
Thawee-wannakij, 2013 ⁵⁵	Thailand, Convenience	20m Rectangle (6x4m), Far as possible	1 trial, Rest between trials if needed, N/A	Yes, at 1, 3, 5 min	M: 24±3	M	60-69	96	390±65 (198-603)
					M: 23±3		70-79	180	368±81 (104-602)
					M: 23±3		≥80 ^{II}	44	307±92 (115-479)
					W: 25±3	W	60-69	320	366±65 (198-547)
					W: 24±3		70-79	329	322±67 (144-485)
					W: 22±2		≥80 ^{II}	61	256±92 (72-515)
Rikli, 1999 ⁷²	USA, Convenience	45.7m, Straight indoor or outdoors, NR	1 trial, A practice test was given prior to the test day [¶] , N/A	Yes, 30 sec	M: 27±4 W: 26±5	M	60-64	144	537±119
							65-69	281	616±84
							70-74	294	577±94
							75-79	230	560±93
							80-84	130	508±115
							85-89	60	479±110
							90-94	48	436±130
						W	60-64	356	486±109
							65-69	617	551±77
							70-74	728	519±92
							75-79	513	501±90
							80-84	276	465±104
							85-89	152	423±107
							90-94	79	390±118
Lusardi, 2003 ⁴⁹	USA, Convenience	82.3m, Straight, Comfortable pace	1 trial, N/A, N/A	NR	NR	M	60-69	1	498 (296-700)
							70-79	9	475±93 (408-543)
						W	60-69	5	405±110 (315-496)
							70-79	10	406±95 (342-470)
						P	80-89	24	328±102 (291-365)

							90-101	7	324±70 (256-393)
Casanova, 2011 ³⁷	Brazil, NR	30m, Straight, ATS*	2 trials, ≥20 min, Maximum distance	ATS [†]		M W	P: 60 (40,80) [#]	25 22	638±95
	Chile					M W	P: 60 (41,78) [#]	20 20	550±77
	Columbia					M W	P: 59 (42,77) [#]	19 20	632±63
	Spain (Pamplona)					M W	P: 52 (40,77) [#]	34 32	624±73
	Spain (Tenerife)					M W	P: 57 (42,77) [#]	20 20	613±75
	Spain (Zaragoza)					M W	P: 55 (41,77) [#]	20 20	510±81
	USA (Boston)					M W	P: 61 (47,75) [#]	31 31	557±87
	USA (Tampa)					M W	P: 57 (41,74) [#]	46 11	535±77
	Uruguay					M W	P: 59 (41,76) [#]	11 16	590±80
	Venezuela					M W	P: 56 (42,71) [#]	12 14	510±39
	Pooled				P: 27±4	M W	P: 58 (42,76) [#]	238 206	571±90 (380-782)

Abbreviations: No., number; m², meters squared; m, meters; BMI, body mass index; SD, standard deviation; min, minutes; NR, not reported; P, pooled; M, men; W, women; HR, heart rate; ATS, American Thoracic Society; sec, seconds; N/A, not applicable.

*ATS Statement, Instructions (Pace): The object of this test is to walk as far as possible for 6 minutes.

[†]ATS Statement, Encouragement: After the first min, tell the patient the following (in even tones): "You are doing well. You have 5 min to go."

When the timer shows 4 min remaining, tell the patient the following: "Keep up the good work. You have 4 min to go." When the timer shows 3 min remaining, tell the patient the following: "You are doing well. You are halfway done." When the timer shows 2 min remaining, tell the patient the following: "Keep up the good work. You have only 2 min left." When the timer shows only 1 min remaining, tell the patient: "You are doing well. You have only 1 min to go."

[‡]Results presented as mean (95% confidence interval).

[§]Results presented as mean (5th percentile).

^{||}Authors pooled results from 7 participants aged ≥90 years with those from participants aged 80-89 years.

[¶]Data obtained from author.

[#]Results presented as median (5th, 95th percentiles).

Table 2. Study, walk test protocol and participant characteristics and descriptive results for distance-limited walk tests (n=18)

First author, Year	Country, Sampling Method, Walk Test	Walk Test Protocol				Participants				Results
		Distance (m)	Timing Method	Pace	No. Trials, Scoring	BMI*, (kg/m ²) Mean±SD	Sex	Age (years) Mean±SD (Range) or Range	n	Gait Speed (m/s) Mean±SD (Range)
El Haber, 2008 ⁵³	Australia, NR, 6mWT-CSA	TD: 6 AD: 1 DD: 1	CSA	Comfortable	1 trial	WT:71±17 HT:167±6	W	21-30	22	1.27±0.15
						WT:66±10 HT:160±5		31-40	31	1.31±0.21
						WT:68±15 HT:162±6		41-50	59	1.38±0.20
						WT:69±14 HT:161±6		51-60	51	1.25±0.20
						WT:68±11 HT:160±6		61-70	28	1.26±0.28
						WT:67±13 HT:158±6		71-82	21	1.04±0.15
Butler, 2009 ⁴⁴	Australia, Convenience, 6mWT	TD: 6 AD: 2 DD: 2	Stop-Watch	Comfortable	1 trial	NR	M	20-39	23	1.50 (1.20-1.60) [†]
							W	20-39	27	1.40 (1.30-1.60) [†]
Lythgo, 2011 ⁵⁷	Australia, NR, 4.3mWT-GR 4.9mWT-GR	TD: 4.3/ 4.9 AD: ≥4 DD: ≥4	Gaitrite	Slow, Free and Fast	Average of 8 and 6 walks over 4.3m and 4.9m-GR mat, respectively, at each speed.	WT:73±10 HT: 179±8	M	NR	28	NR
						WT: 59±8 HT:164±7	W	NR	53	NR
						WT:64±11 HT: 169±10	P	20±2	81	Slow GS: 1.18±0.15 (±0.03) [†] Free GS: 1.52±0.15 (±0.03) [†] Fast GS: 1.95±0.17 (±0.04) [†]
Novaes, 2011 ²⁹	Brazil, Convenience, 10mWT	TD: 10 AD: 1.2 DD: 1.2	Stop-watch	Comfortable	3 trials, Maximum gait speed	P: 24±3	M	40-49	9	1.35±0.11 Equation, Table 3
								50-59	13	1.34±0.22
								60-69	11	1.26±0.15
								≥70	10	1.09±0.18

							W	40-49	11	1.27±0.20
								50-59	8	1.27±0.15
								60-69	9	1.07±0.17
								≥70	8	1.02±0.10
Auvinet, 2002 ⁴⁵	France, Convenience, 40mWT-ACC	TD: 40 AD: NR DD: NR	Stop-watch, synchronized with a gait data logger	Comfortable	20.48s of steady state walking was selected (~28m)	WT: 74±9 HT: 173±7	M	20 to >70	106 ^s	1.51±0.16
							W	20 to >70	103 ^s	1.44±0.17
						WT: 58±8 HT: 162±6	M	20-29	24	1.59±0.13
								30-39	26	1.54±0.12
								40-49	22	1.63±0.15
								50-59	25	1.42±0.08
								60-69	28	1.47±0.11
								>70	13	1.32±0.12
							W	20-29	25	1.54±0.12
								30-39	27	1.56±0.11
								40-49	29	1.50±0.10
								50-59	24	1.48±0.12
								60-69	25	1.35±0.09
								>70	14	1.32±0.12
Kimura, 2007 ⁵⁴	Japan, NR, 3mWT-CS	TD: 3 AD: ~2 DD: ~2	CS	Comfortable	NR	M: 23±4	M	21±2	10	1.34±0.20 Equation, Table 3
						M: 24±3		72±4	25	1.19±1.70
						W: 21±3	W	22±1	10	1.30±0.12
						W: 24±3		69±3	27	1.23±1.60
Oberg, 1993 ⁴⁶	Sweden, NR, 5.5mWT	TD: 5.5 AD: NR DD: NR	NR	Slow	10 trials	NR	M	20-29	15	0.83±0.09 (0.78–0.88) [†]
								30-39	15	0.88±0.19 (0.78–0.99) [†]
								40-49	15	0.94±0.10 (0.88–0.99) [†]
								50-59	15	0.86±0.16 (0.77–0.95) [†]
								60-69	15	0.88±0.13 (0.81–0.95) [†]
								70-79	14	0.80±0.14 (0.72–0.87) [†]
							W	20-29	15	0.84±0.20 (0.73–0.94) [†]

								30-39	15	0.87±0.16 (0.78-0.95) [†]
								40-49	15	0.79±0.18 (0.69-0.89) [†]
								50-59	15	0.73±0.16 (0.64-0.81) [†]
								60-69	15	0.74±0.18 (0.64-0.84) [†]
								70-79	15	0.74±0.10 (0.68-0.79) [†]
							M	20-29	15	1.22±0.11 (1.17-1.29) [†]
								30-39	15	1.31±0.15 (1.23-1.40) [†]
								40-49	15	1.33±0.10 (1.28-1.38) [†]
								50-59	15	1.25±0.18 (1.16-1.35) [†]
								60-69	15	1.28±0.12 (1.21-1.34) [†]
								70-79	14	1.18±0.15 (1.10-1.27) [†]
							W	20-29	15	1.24±0.17 (1.15-1.33) [†]
								30-39	15	1.29±0.19 (1.18-1.40) [†]
								40-49	15	1.11±0.14 (1.17-1.33) [†]
								50-59	15	1.11±0.10 (1.05-1.16) [†]
								60-69	15	1.16±0.17 (1.07-1.25) [†]
								70-79	15	1.11±0.13 (1.05-1.18) [†]
				Fast			M	20-29	15	1.63±0.20 (1.52-1.74) [†]
								30-39	15	1.77±0.29 (1.61-1.92) [†]
								40-49	15	1.72±0.18 (1.62-1.81) [†]
								50-59	15	1.64±0.25 (1.51-1.77) [†]
								60-69	15	1.64±0.20 (1.53-1.75) [†]
								70-79	14	1.59±0.25 (1.45-1.73) [†]
							W	20-29	15	1.69±0.23 (1.57-1.82) [†]
								30-39	15	1.72±0.28 (1.57-1.87) [†]
								40-49	15	1.67±0.18 (1.57-1.76) [†]
								50-59	15	1.47±0.18 (1.37-1.57) [†]
								60-69	15	1.56±0.23 (1.43-1.68) [†]
								70-79	15	1.42±0.17 (1.32-1.52) [†]
Thaweewannakij, 2013 ⁵⁵	Thailand, Convenience, 3mWT	TD: 3 AD: 3.5 DD: 3.5	NR	Comfortable	2 trials, Average	M: 24±3	M	60-69y	96	1.16±0.21 (0.74-1.87) 95%CI: 1.12-1.20
						M: 23±3		70-79y	180	1.09±0.20 (0.65-1.80) 95%CI: 1.06-1.12
						M: 23±3		≥80y	44 ^{II}	0.97±0.20 (0.56-1.40)

										95%CI: 0.92-1.04
						W: 25±3	W	60-69y	320	1.08±0.15 (0.73-1.67) 95%CI: 1.07-1.10
						W: 24±3		70-79y	329	0.99±0.15 (0.61-1.51) 95%CI: 0.97-1.01
						W: 22±2		≥80y	61 ^{II}	0.88±0.18 (0.31-1.33) 95%CI: 0.84-0.93
				Fast	2 trials, Average	M: 24±3	M	60-69y	96	1.48±0.25 (0.97-2.41) 95%CI: 1.43-1.53
						M: 23±3		70-79y	180	1.38±0.25 (0.81-2.23) 95%CI: 1.34-1.42
						M: 23±3		≥80y	44 ^{II}	1.26±0.24 (0.80-1.87) 95%CI: 1.19-1.34
						W: 25±3	W	60-69y	320	1.32±0.20 (0.82-2.15) 95%CI: 1.30-1.34
						W: 24±3		70-79y	329	1.21±0.19 (0.72-1.99) 95%CI: 1.19-1.23
						W: 22±2		≥80y	61 ^{II}	1.10±0.25 (0.31-1.50) 95%CI: 1.03-1.16
Samson, 2001 ³⁶	The Netherlands, NR, 3.5mWT-IRS	TD: 3.5 AD:~4.25 DD:~4.25	IRS	Comfortable	NR – assuming 1	NR	M	20-29	All 121	1.56±0.15 ^{II} Equation, Table 3
								30-39		1.55±0.14 ^{II}
								40-49		1.48±0.13 ^{II}
								50-59		1.46±0.15 ^{II}
								60-69		1.46±0.19 ^{II}
								70-79		1.36±0.18 ^{II}
								80-89		1.25±0.19 ^{II}
							W	20-29	All 118	1.50±0.11 ^{II} Equation, Table 3
								30-39		1.49±0.09 ^{II}
								40-49		1.47±0.14 ^{II}
								50-59		1.43±0.19 ^{II}
								60-69		1.42±0.11 ^{II}
								70-79		1.30±0.17 ^{II}
								80-89		1.18±0.14 ^{II}
Hageman, 1986 ⁷¹	USA, NR,	TD: 3.25 AD:4.75	CS	Comfortable	3 trials, Average	WT: 60±8 HT: 165±8	W	24±4 (20-33)	13	1.60±0.16

	3.3mWT-CS	DD:6				WT: 61±17 HT: 161±9	W	67±8 (60-84)	13	1.32±0.24
Blanke, 1989 ⁵⁶	USA, NR, 3.3mWT-CS	TD: 3.25 AD:4.75 DD:6	CS	Comfortable	3 trials, Average	WT: 77±7 HT: 176±9	M	25±4 (20-33)	12	1.31±0.18
						WT: 77±7 HT: 176±9	M	64±6 (60-74)	12	1.39±0.23
Bohannon, 1996 ⁴⁷	USA, Convenience, 7.6mWT	TD:~7.62 AD: Y, several meters DD: Y, several meters	Stop- watch	Comfortable	4 trials, 2 trials at each speed, Average at each speed	WT, M: 784±106N	M	50-79 64±8	77	1.41±0.21 (0.94–2.02) Equation, Table 3
				Fast		WT, W: 643±109N	W	50-79 64±8	79	1.31±0.20 (0.71-1.88)
						HT, M: 175±6	M	50-79 64±8	77	2.22±0.42 (1.28–3.20) Equation, Table 3
						HT, W: 161±6	W	50-79 64±8	79	1.81±0.32 (1.02–2.76)
Bohannon, 1997 ⁴⁸	USA, Convenience, 7.6mWT	TD: 7.62 AD: Y, several meters DD: Y, several meters	Stop- Watch	Comfortable	4 trials, 2 trials at each speed, initial walk test score at each speed	NR	M	20-29	15	1.39
								30-39	13	1.46
								40-49	22	1.46
								50-59	22	1.39
								60-69	18	1.36
								70-79	22	1.33
							W	20-29	22	1.41
								30-39	23	1.41
								40-49	21	1.39
								50-59	21	1.40
								60-69	18	1.30
								70-79	20	1.27
				Fast			M	20-29	15	2.53
								30-39	13	2.46
								40-49	22	2.46
								50-59	22	2.07
								60-69	18	1.93
								70-79	22	2.08
							W	20-29	22	2.47
								30-39	23	2.34
								40-49	21	2.12
								50-59	21	2.01
								60-69	18	1.77
								70-79	20	1.75

Lusardi, 2003 ⁴⁹	USA, Convenience, 3.7mWT-GR	TD: 3.66 AD: 3 DD: 3	Gaitrite	Comfortable	6 trials, 3 trials at each speed, Average at each speed	NR	M	60-69	1	1.26 (0.84-1.67) [†]
								70-79	9	1.25±0.23 (1.11-1.39) [†]
							W	60-69	5	1.24±0.12 (1.05-1.42) [†]
								70-79	10	1.25±0.18 (1.11-1.38) [†]
							P	80-89	24	0.91±0.16 (0.84-0.98) [†]
								90-100	7	0.88±0.23 (0.76-1.01) [†]
				Fast			M	60-69	1	1.96 (1.37-2.56) [†]
								70-79	9	1.94±0.26 (1.74-2.14) [†]
							W	60-69	5	1.81±0.17 (1.55-2.08) [†]
								70-79	10	1.80±0.26 (1.61-1.99) [†]
Chui, 2010 ⁵¹	USA, Convenience, 3.7mWT-GR	TD:3.66 AD: 3.5 DD: 3.5	Gaitrite	Self-selected	6 trials, 3 successful trials at each speed, Average at each speed	M: 28±4 W: 30±4	M	70-79	4	1.55±0.58 (1.19-1.92) [†]
								80-89	26	1.30±0.15 (1.20-1.39) [†]
								90-100	5	1.09±0.38 (0.85-1.33) [†]
							W	70-79	15	1.34±0.25 (1.18-1.50) [†]
								80-89	51	1.05±0.12 (0.98-1.13) [†]
								90-100	17	0.80±0.17 (0.69-0.90) [†]
				Fast			M	70-79	4	2.19±0.78 (1.70-2.67) [†]
								80-89	26	1.74±0.20 (1.62-1.87) [†]
								90-100	5	1.55±0.66 (1.13-1.96) [†]
							W	70-79	15	1.68±0.32 (1.48-1.88) [†]
								80-89	51	1.44±0.17 (1.33-1.55) [†]
								90-100	17	1.05±0.21 (0.92-1.19) [†]
Oh-Park, 2010 ⁵⁰	USA, NR, 4.6mWT-GR	TD: 4.57 AD:0.91 DD:0.91	Gaitrite	Normal	2 trials, Average	NR	M	70-74	NR	1.12±0.20
								75-79	NR	1.12±0.18
								80-84	NR	1.08±0.17
								≥85	NR	1.02±0.18
							W	70-74	NR	1.10±0.16
								75-79	NR	1.02±0.19
								80-84	NR	1.00±0.16
								≥85	NR	1.01±0.15
Hollman, 2011 ⁵²	USA, Random, 5.6mWT-GR	TD: 5.6 AD: 1 DD: 1	Gaitrite	Normal	2 trials, Average	M: 28±4 W: 26±4	M	70-74	27	1.17±0.00
								75-79	30	1.12±0.15
								80-84	37	1.12±0.17
								≥85	14	1.01±0.22
							W	70-74	33	1.16±0.20
								75-79	77	1.12±0.17

								80-84	43	1.01±0.15
								≥85	33	0.98±0.20
Wilken, 2012 ⁵⁸	USA, NR, 10mWT	TD: 10 AD:5 DD:5	Stop- watch	Comfortable	3 trials, Average	NR	M	25±6 (18-43)	130	1.51±0.17 (1.0-1.93) 95%CI: 1.48-1.54
							W	25±5 (18-40)	50	1.19±0.14 (0.86-1.54) 95%CI: 1.43-1.53

Abbreviations: meter squared; SD, standard deviation; m/s, meters per second; NR, not reported; CSA, clinical stride analyzer; TD, test distance; AD, acceleration distance; DD, deceleration distance; WT, weight; HT, height; W, women; M, men; GR, gaitrite; P, pooled; ACC, accelerometer; CS, camera system; IRS, infrared reflective system; Y, yes; N, Newtons.

* If BMI was not reported, weight and height are reported in kg and cm, respectively, unless otherwise noted.

† Median (Interquartile Range)

‡ Mean±SD (95% Confidence Interval)

§ Although 282 people entered the study, the total sample size for gait speed analysis was n=209 including 103 women but authors do not report the sample sizes per decade. Thus, it is difficult to determine which decade may have a less precise estimate owing to a smaller sample size. Also, authors did not examine relationships between walk test performance and height and weight although they had the data.

|| Authors pooled results from 7 participants aged ≥90 years with those from participants aged 80-89 years.

¶ Results presented as mean±standard error

Table 3. Reference equations for time- and distance-limited walk tests (n=24)

First author, Year	Country	Sex	N	Score Modelled	Reference Equation	R ²
6 MWT Distance (6 MWD) in meters (20 studies)						
Casanova, 2011³⁷	Brazil, Chile, Columbia, Spain, Uruguay, USA, Venezuela (pooled)	M	238	Maximum of 2 trials	6 MWD = 361 – 4 (age in yrs) + 2 (height in cm) – 1.5 (weight in kg) + 3 (HR _{max} /%predHR _{max})	0.38
		W	206		6 MWD = 361– 4 (age in yrs) + 2 (height in cm) – 1.5 (weight in kg) + 3 (HR _{max} /%predHR _{max}) – 30	0.38
Camarri, 2006⁵⁹	Australia	P	70	Maximum of 3 trials	6 MWD = 64.69 + 3.12 (height in cm) + 23.29 (FEV ₁ in litres)	0.34
		P	70		6 MWD = 216.90 – 1.75 (age in yrs) – 34.04 (sex, men=0; women=1) + 4.12 (height in cm) – 1.15 (weight in kg)	0.36
Jenkins, 2009⁷⁴	Australia	M	48	Maximum of 2 trials	6 MWD = 867 - 5.71 (age in yrs) + 1.03 (height in cm)	0.40
		M	48		6 MWD = 748 – 6.32 (age in yrs) + 0.64 (height in cm) + 2.69 (%predHR _{max})	0.61
		M	48	Trial 1	6 MWD = 1005 – 5.68 (age in yrs) + 0.89 (height in cm)	0.34
		M	48		6 MWD = 849 – 6.15 (age in yrs) + 0.22 (height in cm) + 2.12 (%predHR _{max})	0.47
		W	61	Maximum of 2 trials	6 MWD = 525 – 2.86 (age in yrs) + 2.71 (height in cm) – 6.22 (BMI in kg/m ²)	0.43
		W	61		6 MWD = 541 - 3.81 (age in yrs) + 1.80 (height in cm) – 6.92 (BMI in kg/m ²) + 2.41 (%predHR _{max})	0.58
		W	61	Trial 1	6 MWD = 602 – 2.97 (age in yrs) + 2.05 (height in cm) – 5.50 (BMI in kg/m ²)	0.35
		W	61		6 MWD = 594 – 3.95 (age in yrs) + 1.09 (height in cm) – 5.69 (BMI in kg/m ²) + 2.69 (%predHR _{max})	0.50
Troosters, 1999⁶⁰	Belgium	P	51	Maximum of 2 trials	6 MWD = 218 – 5.32 (age in yrs) + 51.31 (sex, men=1; women=0) + 5.14 (height in cm) – 1.80 (weight in kg)	0.66
Iwama, 2009⁶¹	Brazil	P	134	2 nd of 2 trials	6 MWD = 622.461 - 1.846 (age in yrs) + 61.503 (sex, men=1; women=0)	0.30
Dourado, 2011⁷⁵	Brazil	P	90	NR	6 MWD = 299.296 – 2.728 (age in yrs) + 56.386 (sex, men=1; women=0) + 361.731 (height in m) – 2.160 (weight in kg)	0.54
Soares, 2011⁶⁹	Brazil	P	132 [¶]	Maximum of 3 trials	6 MWT = 511 – 0.030 (age in yrs) ² + 0.0066 (height in cm) ² – 0.068 (BMI in kg/m ²) ²	0.55
Steffens, 2013⁷⁰	Brazil	W	77	Maximum of 2 trials	6 MWD = 963.04 – 4.71 (age in yrs) – 5.07 (BMI in kg/m ²) + 43.25 (group, sedentary=0; active=1)	NR
Dourado,	Brazil	M	39	2 nd of 2 trials	6 MWD = 343.64 x (weight in kg) ^{0.11} (men aged 40-59 yrs)	0.35

2012 ⁷³		M	19		6 MWD = 144.02 x (weight in kg) ^{0.35} (men aged ≥60 yrs)	0.30
		M	39		6 MWD = 80.82 x (weight in kg) ^{0.08} x (height in cm) ^{0.31} (men aged 40-59 yrs)	0.41
		M	19		6 MWD = 8.67 x (weight in kg) ^{0.26} x (height in cm) ^{0.62} (assuming men aged ≥60 yrs)	
		W	41		6 MWD = 317.66 x (weight in kg) ^{0.11} (women aged 40-59 yrs)	0.35
		W	21		6 MWD = 118.39 x (weight in kg) ^{0.35} (women aged ≥60 yrs)	0.30
		W	41		6 MWD = 76.40 x (weight in kg) ^{0.08} x (height in cm) ^{0.31} (women aged 40-59 yrs)	
		W	21		6 MWD = 7.46 x (weight in kg) ^{0.26} x (height in cm) ^{0.62} (assuming women aged ≥60 yrs)	0.40
Hill, 2011 ³¹	Canada	P	77	Maximum of 2 trials	6 MWD = 970.7 - 5.5 (age in yrs) + 56.3 (sex, men=1; women=0)	0.49
Gibbons, 2001 ⁶²	Canada	P	79	Maximum of 4 trials	6 MWD = 868.8 – 2.99 (age in yrs) – 74.7 (sex, men=0; women=1)	0.41
Osses, 2010 ⁷⁶	Chile	M	77	NR	6 MWD = 530 - 3.31 (age in yrs) + 2.36 (height in cm) - 1.49 (weight in kg)	0.55
		W	98		6 MWD = 457 - 3.46 (age in yrs) + 2.61 (height in cm) - 1.57 (weight in kg)	0.63
Vaish, 2013 ⁶⁴	India	M	101	Trial 1	6 MWD = 127.121 – 4.139 (age in yrs) + 3.654 (height in cm)	0.64
Chetta, 2006 ⁶⁵	Italy	P	102	2 nd of 2 trials	6 MWD = 518.853 – 2.186 (age in yrs) + 1.250 (height in m) – 39.07 (sex, men=0; women=1)	0.42
Padron, 2000 ⁷⁷	Mexico	P	200	Trial 1	Fast 6 MWD = 665.327 – 0.656 (age in yrs) + 46.842 (sex, men=1; women=0) – 3.070 (BMI in kg/m ²)	0.21
		P	200		Slow 6 MWD = 492.37 – 0.113 (age in yrs) + 19.18 (sex, men=1; women=0) – 1.004 (BMI in kg/m ²)	0.04
Alameri, 2009 ⁶⁶	Saudi Arabia	P	190	Trial 1	6 MWD = -28.5 + 0.79 (age in yrs) + 2.81 (height in cm)	0.25
Poh, 2006 ³⁸	Singapore	P	35	Maximum of 3 trials	6 MWD = – 473.27 – 4.49 (age in yrs) + 6.94 (height in cm) – 3.51 (weight in kg) + 5.50 (%predHR _{max})	0.78
Masmoudi, 2008 ⁷⁸	Tunisia	P	155	Maximum of 2 trials	6 MWD = 299.8 – 4.34 (age in yrs) + 62.5 (sex, men=1; women=0) + 342.6 (height in m) – 1.46 (weight in kg)	0.60
		P	155		6 MWD = 852.7 – 4.55 (age in yrs) + 90.8 (sex, men=1; women=0) – 3.8 (BMI in kg/m ²)	0.58
Ben Saad, 2009 ⁶⁷	Tunisia	M	104	Maximum of 2 trials	6 MWD = 905.45 – 5.40 (age in yrs) - 160.27 (sex, 0) + 171.60 (height in m) – 2.22 (weight in kg)	0.53
		W	125		6 MWD = 397.40 – 4.99 (age in yrs) – 160.27 (sex, 1) + 378.87 (height in m) – 2.41 (weight in kg)	0.52
		P	229		6 MWD = 720.50 – 5.14 (age in yrs) - 160.27 (sex, men=0, women=1) +	0.77

					271.98 (height in m) – 2.23 (weight in kg)	
Enright, 1998 ⁶⁸	USA	M	117	Trial 1	6 MWD = – 309 – 5.02 (age in yrs) + 7.57 (height in cm) – 1.76 (weight in kg)	0.42
					6 MWD = 1,140 – 6.94 (age in yrs) - 5.61 (BMI in kg/m²)	
		W	173		6 MWD = 667 – 5.78 (age in yrs) + 2.11 (height in cm) – 2.29 (weight in kg)	0.38
					6 MWD = 1,017 – 5.83 (age in yrs) – 6.24 (BMI in kg/m²)	
Gait speed (GS) in meters/second (4 studies)						
Novaes, 2011 ²⁹	Brazil 10mWT	P	79	Maximum of 3 trials	Comfortable GS = 1.662 - 0.008 (age) + 0.115 (sex, men=1; women=0)	0.25
Kimura, 2007 ⁵⁴	Japan 3mWT-CS	P	52	NR	Comfortable GS (elderly) = 2.307 – 0.016 (age in yrs)	0.11
Samson, 2001 ³⁶	The Netherlands 3.5mWT-IRS	M	121	NR	Comfortable GS = 0.720 – 0.001 (age in yrs) + 0.486 (height in cm) – 0.001 (weight in kg)	0.09
		W	118		Comfortable GS = 0.316 – 0.001 (age in yrs) + 0.827 (height in cm) – 0.003 (weight in kg)	0.18
Bohannon, 1996 ⁴⁷	USA 7.62mWT 7.62mWT	P	156	Mean of 2 trials	Comfortable GS = 149.65 – 7.65 (sex, men=0; women=1) – 0.04 (weight in Newtons) + 0.21 (strength of hip flexion non-dominant side in Newtons)	0.13
		P	156		Fast GS = 235.71 – 29.55 (sex, men=0; women=1) – 0.08 (weight in Newtons) + 0.21 (strength of hip flexion dominant side in Newtons)	0.21

Abbreviations: M, men; yrs, years; cm, centimeters; kg, kilograms; HR_{max}, maximum heart rate; %predHR_{max}, percentage of the predicted maximum heart rate; W, women; P, pooled (men/women combined); FEV₁, forced expiratory volume in 1 second; BMI, body mass index; kg/m², kilogram per meters squared; NR, not reported; mWT, meter walk test; CS, camera system; IRS, infrared reflective system.

*The exponents in the equation are the allometric correction exponents.

Figure Legends

Figure 1: Process of study selection.

Figure 2: Quality appraisal (COSMIN) for studies examining time-limited walk tests (n=25).

Abbreviations: I, Interpretability Checklist; G, Generalisability Checklist; +, Yes; -, No; ?, Can't Tell. Important flaws across included studies commonly related to insufficient description of the walk test protocol thus limiting replication.

Figure 3: Quality appraisal (COSMIN) for studies examining distance-limited walk tests (n=18).

Abbreviations: I, Interpretability Checklist; G, Generalisability Checklist; +, Yes; -, No; ?, Can't Tell. Important flaws across included studies commonly related to insufficient description of the walk test protocol thus limiting replication.

Legends for Supplementary Figures

Figure 1S: Mean 6MWT distance in men by age decade and country (4 studies; descriptive data).

Numbers above the vertical bars indicate the sample size in each study. *Descriptive data presented for two 4-year age intervals in each age decade were averaged to obtain result for age decade.

Figure 2S: Mean 6MWT distance in women by age decade and country (4 studies; descriptive data). Numbers above the vertical bars indicate the sample size in each study. *Descriptive data presented for two 4-year age intervals in each age decade were averaged to obtain result for age decade.

Figure 3S: Mean walking speed at a comfortable pace in men by age decade and country (7 studies; descriptive data). Numbers above the vertical bars indicate the sample size in each study. Abbreviations: NR, not reported. *Descriptive data presented for two 4-year age intervals in each age decade were averaged to obtain result for age decade.

Figure 4S: Mean walking speed at a comfortable pace in women by age and country (7 studies; descriptive data). Numbers above the vertical bars indicate the sample size in each study.

*Descriptive data presented for two 4-year age intervals in each age decade were averaged to obtain result for age decade.

	I: Adequate sample size	I: Distribution of scores	I: Scores & change scores for relevant sub-groups	I: Important flaws	G: Median or mean Age	G: Distribution of sex	G: Study Setting	G: Geographical location of study (country)	G: Method used to select participants
Alameri et al., 2009	+	+	+	-	+	+	+	+	+
Ben Saad et al., 2009	+	+	+	-	+	+	+	+	-
Camarri et al., 2006	+	+	+	-	+	+	+	+	+
Casanova et al., 2011	+	+	-	-	+	+	+	+	-
Chetta et al., 2006	+	+	+	-	+	+	+	+	-
Dourado et al., 2011	+	+	+	-	+	+	+	+	+
Dourado et al., 2012	-	+	+	-	+	+	+	+	+
Enright et al., 1998	+	+	+	-	+	+	+	+	+
Gibbons et al., 2001	-	+	+	-	+	+	+	+	+
Hill et al., 2001	+	+	+	-	+	+	+	+	-
Iwama et al., 2009	+	+	+	-	+	+	+	+	+
Jenkins et al., 2009	-	+	+	-	+	+	+	+	-
Luna et al., 2000	-	-	+	-	+	+	-	+	-
Lusardi et al., 2003	-	+	-	-	+	+	+	+	+
Masmoudi et al., 2005	+	+	+	-	+	+	+	+	-
Osses et al., 2010	+	+	+	-	+	+	+	+	-
Poh et al., 2006	-	+	+	-	+	+	+	+	-
Rikli et al., 1999	+	+	+	-	+	+	+	+	-
Soares et al., 2011	+	-	-	-	-	+	+	+	+
Steffens et al., 2013	+	+	+	-	+	+	+	+	+
Suwanachaiy et al., 2010	+	+	+	-	+	+	+	+	-
Thaweeewannakij et al., 2013	+	+	+	-	+	+	+	+	+
Troosters et al., 1999	+	+	+	-	+	+	+	+	-
Tsang et al., 2005	+	+	+	-	+	+	+	+	+
Vaish et al., 2013	+	+	+	-	+	+	+	+	+

	I: Adequate sample size	I: Distribution of scores	I: Scores & change scores for relevant sub-groups	I: Important flaws	G: Median or mean age	G: Distribution of sex	G: Study setting	G: Geographical location of study (country)	G: Method used to select participants
Auvinet et al., 2002	?	+	+	-	+	+	+	+	-
Blanke et al., 1989	-	+	+	-	+	+	-	+	-
Bohannon et al., 1996	+	+	+	-	+	+	-	-	+
Bohannon et al., 1997	+	+	+	-	+	+	-	+	-
Butler et al., 2009	+	+	+	-	+	+	+	+	+
Chui et al., 2010	+	+	+	-	+	+	+	+	-
El Haber et al., 2008	+	+	+	-	+	+	+	+	-
Hageman et al., 1996	-	+	+	-	+	+	-	+	-
Hollman et al., 2011	+	+	+	-	+	+	+	+	+
Kimura et al., 2007	+	+	+	-	+	+	+	+	-
Lusardi et al., 2003	-	+	-	-	+	+	+	+	+
Lythgo et al., 2011	+	+	-	-	+	+	+	+	-
Novaes et al., 2011	-	+	+	-	+	+	-	+	-
Oberg et al., 1993	+	+	+	-	-	+	-	+	-
Oh-Park et al., 2010	?	+	+	-	+	+	+	+	-
Samson et al., 2001	?	-	+	-	+	+	+	+	-
Thaweewannakij et al., 2013	+	+	+	-	+	+	+	+	+
Wilken et al., 2012	+	+	+	-	+	+	+	+	-

Supplementary Tables and Figures

Table 1S: List of unique walking speed tests ordered by timing technology

Walk Test	Timing Technology	Abbreviation	References
3-meter walk test	Stopwatch	3mWT	Thaweewannakji, 2013 ⁵⁵
5.5-meter walk test	Stopwatch	5.5mWT	Oberg, 1993 ⁴⁶
6-meter walk test	Stopwatch	6mWT	Butler, 2009 ⁴⁴
7.6-meter walk test	Stopwatch	7.6mWT	Bohannon, 1996 ⁴⁷ ; Bohannon, 1997 ⁴⁸
10-meter walk test	Stopwatch	10mWT	Wilken, 2012 ⁵⁸ ; Novaes, 2011 ²⁹
3.7-meter walk test	GaitRite	3.7mWT-GR	Lusardi, 2003 ⁴⁹ Chui, 2010 ⁵¹
4.3-meter walk test	GaitRite	4.3mWT-GR	Lythgo, 2011 ⁵⁷
4.6-meter walk test	GaitRite	4.6mWT-GR	Oh-Park, 2010 ⁵⁰
4.9-meter walk test	GaitRite	4.9WT-GR	Lythgo, 2011 ⁵⁷
5.6-meter walk test	GaitRite	5.6mWT-GR	Hollman, 2011 ⁵²
3-meter walk test	Camera System	3mWT-CS	Kimura, 2007 ⁵⁴
3.3-meter walk test	Camera System	3.3mWT-CS	Blanke, 1989 ⁵⁶ ; Hageman, 1986 ⁷¹
3.5-meter walk test	Infrared Reflective System	3.5mWT-IRS	Samson, 2001 ³⁶
6-meter walk test	Clinical Stride Analyser	6mWT-CSA	El Haber, 2008 ⁵³

40-meter walk test	Accelerometer	40mWT-ACC	Auvinet, 2002 ⁴⁵
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Table 2S. Study, walk test protocol and participant characteristics for studies reporting references equations for the 6-min walk test (n=10)

First author, Year	Country, Sampling Method	Walk Test Protocol			Participants			
		Path Distance, Shape, Pace*	No. Trials, Rest Time, Scoring	Encouragement, Interval	n	Sex	Age (years) Mean±SD (Range)	BMI (kg/m ²) Mean±SD (Range)
Troosters, 1999 ⁶⁰	Belgium, Convenience	50m, Straight, Maximal pace	2 trials, ~2.5 hrs, Maximum distance	Yes, 30 sec	29	M	P: 65±10 (50-85)	P: 26±5
					22	W		
Iwama, 2009 ⁶¹	Brazil, Convenience	30m, Straight, Far as possible	2 trials, ≥30 min, Trial 2	Yes, 1 min	61	M	31 (22-37) [†]	24 (22-27) [†]
					73	W	35 (24-52) [†]	25 (23-29) [†]
					134	P	36±15	25±4
Dourado, 2011 ⁷⁵	Brazil, Convenience	27-30m, Straight, Fast as possible	2 trials, ≥30 min, NR	ATS [†]	40	M	P: 60±9	P: 26±4
					50	W		
Dourado, 2012 ⁷³	Brazil, Convenience	30m Straight, Fast as possible	2 trials, 30 min, Trial 2	ATS [†]	55	M	P: 58±10	P: 26±4
					65	W		
Hill, 2011 ³¹	Canada, Convenience	30m, Straight, ATS*	2 trials, 20-30 min, Maximum distance	ATS [†]	37	M	P: 65±11 (45-85)	P: 26±3 (20-37)
					40	W		
Osses, 2010 ⁷⁶	Chile, Convenience	30m, Straight, ATS*	2 trials, 30 min, NR	ATS [†]	77	M	52±17	27±3
					98	W	56±16	26±4
Chetta, 2006 ⁶⁵	Italy, Convenience	30m, Straight, ATS*	2 trials, ≥60 min, Trial 2	ATS [†] 30 sec	48	M	36±8	25±2
					54	W	33±9	22±3
Masmoudi, 2008 ⁷⁸	Tunisia, NR	30m, Straight, ATS*	2 trials 30 min, Maximum distance	ATS [†]	80	M	57±12 (40-79)	(18-35)
					75	W	53±10 (40-75)	30±5 (20-38)
					155	P	55±11 (40-79)	28±4 (18-38)
Ben Saad, 2009 ⁶⁷	Tunisia, Convenience	40m, Straight, ATS*	2 trials, ~60 min, Maximum distance	No	104	M	55±10	27±3
					125	W	58±11	28±3
					229	P	56±10	28±3
Enright, 1998 ⁶⁸	USA, Random	30.5m, Straight, Own pace	1 trial, N/A, N/A	Yes	117	M	60 (43-77) [†]	28 (22-34) [†]
					173	W	62 (45-79) [†]	26 (21-32) [†]

Abbreviations: No., number; BMI, body mass index; SD, standard deviation; m², meters squared; NR, not reported; min, minutes; M, men; W, women; ATS, American Thoracic Society; P, pooled; N/A, not applicable; sec, seconds.

*ATS Statement, Instructions (Pace): The object of this test is to walk as far as possible for 6 minutes.

†ATS Statement, Encouragement: After the first min, tell the patient the following (in even tones): "You are doing well. You have 5 min to go."

When the timer shows 4 min remaining, tell the patient the following: "Keep up the good work. You have 4 min to go." When the timer shows 3 min remaining, tell the patient the following: "You are doing well. You are halfway done." When the timer shows 2 min remaining, tell the patient the following: "Keep up the good work. You have only 2 min left." When the timer shows only 1 min remaining, tell the patient: "You are doing well. You have only 1 min to go."

‡Results presented as mean (95% confidence interval).

Figure 1S

Figure 2S

Figure 3S

Figure 4S

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