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ORIGINAL ARTICLE

Health-Related Physical Fitness Measures: Reference Values and Reference Equations for Use in Clinical Practice

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Abstract

Objective: To provide reference values and reference equations for frequently used clinical field tests of health-related physical fitness for use in clinical practice.

Design: Cross-sectional design.

Setting: General community.

Participants: Convenience sample of volunteers (N = 370) between 18 and 90 years of age were recruited from a wide range of settings (ie, work sites, schools, community centers for older adults) and different geographic locations (ie, urban, suburban, rural) in southeastern Norway.

Interventions: Not applicable.

Main Outcome Measures: The participants conducted 5 clinical field tests (6-minute walk test, stair test, 30-second sit-to-stand test, handgrip test, fingertip-to-floor test).

Results: The results of the field tests showed that performance remained unchanged until approximately 50 years of age; after that, performance deteriorated with increasing age. Grip strength (79%), meters walked in 6 minutes (60%), and seconds used on the stair test (59%) could be well predicted by age, sex, height, and weight in participants ≥50 years of age, whereas the performance on all tests was less well predicted in participants <50 years of age.

Conclusions: The reference values and reference equations provided in this study may increase the applicability and interpretability of the 6-minute walk test, stair test, 30-second sit-to-stand test, handgrip test, and fingertip-to-floor test in clinical practice.

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People suffering from musculoskeletal conditions (MSCs) tend to be more deconditioned than healthy controls[1,2] and are less likely to fulfill the recommended levels of physical activity.[3] Physical inactivity may lead to increased risk of long-term disability and comorbidity. To meet these challenges, recommendations for management of chronic MSCs are increasingly emphasizing health-related physical fitness as an important treatment target.[4-6] Physical fitness is defined as the characteristics enabling people to perform physical activity with the health-related components of cardiorespiratory endurance, muscle strength, muscle endurance, flexibility, and body composition.[7,8]

A large proportion of patients seen in outpatient physical therapy clinics seek treatment for MSCs.[9] To evaluate patient's health-related physical fitness, clinicians need measurement tools that are applicable in clinical practice.[10] For clinical feasibility, field tests of physical performance that are readily available, time efficient, easy to perform, and require no or only portable equipment can be used.[11] Even if field tests are less accurate and

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specific than the more sophisticated laboratory-based tests, they are shown to be applicable for measuring cardiorespiratory endurance,[12-15] muscle strength,[16-19] and flexibility.[20]

To improve the interpretability and clinical usefulness of clinical field tests, relevant reference values and reference equations are needed. Reference values and reference equations are previously established for tests (eg, 6-minute walk test [6MWT],[12,21-32] handgrip test,[33-36] 30-second sit-to-stand test [30sSTS][37,38]), but these values were derived from studies based on multiple trials and presented only for some specific age groups. For use in clinical practice, reference values and reference equations for men and women in all age groups are needed. The aim of this study was, therefore, to provide age- and sex-specific reference values for health-related physical fitness measures in the general population.

Methods

This study is part of a large-scale research program (FYSIOPRIM, a research program on physiotherapy in primary care) focusing on several methodologic and clinical aspects of physical therapy in primary health care. The research program is developed and led by a group of experienced researchers and clinicians. One of the aims of FYSIOPRIM is to establish a core set of physical fitness measures for use in clinical practice. The predefined criteria for inclusion of fitness measures in the core set were that they had to be applicable in a busy clinical practice (ie, easy to perform, time efficient and require a minimum amount of equipment),[11] making field tests the most clinical feasible tools to use. The selection of relevant field tests was based on a thorough literature search followed by discussions and an informal consensus process in the research group.

A convenience sample of volunteers was included in sex and age groups with 10 year increments (a total of 14 groups). Power calculations were based on the mean of the 6MWT of the first 80 participants in the ongoing data collection (range, 437−714m) with a group SD of approximately 83m. The significance level was set to .05, and the required power was set to at least .80. The sample size was estimated to 20 to 25 participants per group. The recruitment period lasted from June 2011 to August 2012.

To ensure a representative sample, participants were included from a wide range of settings (ie, work sites, schools, community centers for older adults) and different geographic locations (ie, urban, suburban, rural), mainly in the southeast part of Norway. Participants from different work sites were recruited to cover different professions. When approval was given from the general manager or a superior at the site, the employees, users of community centers, students, and so forth were asked to volunteer. In addition, people were also recruited from other settings (network connections) to capture other workplaces and people who were retired but not visiting community centers for older adults (fig 1).

Two physical therapists (A.T.T. and T.M.) tested all the participants. Pilot testing was conducted before the study, and all participants were tested according to a standardized test protocol. To be included, the participants had to be ≥18 years old, understand written and spoken Norwegian language, and live at home. Participants with self-reported serious heart disease or other diseases that restricted participation in moderate physical activity were not included. Participants who were unable to climb stairs were excluded. We considered this the most demanding test and expected the participants to be able to complete the other tests if they could complete the stair test.

All participants answered a set of sociodemographic questions, including age, sex, employment status, occupation, smoking habits, and comorbidities. Body composition was measured by body weight and height and was presented as body mass index (BMI) (kg/m^2). To assess physical activity level, the participants answered the International Physical Activity Questionnaire Short Form,[39] consisting of 7 questions on the time spent in vigorous-intensity activities, moderate-intensity activities, walking and sedentary activities. The results were transformed into metabolic equivalent task minutes per week scores and categorized into low, moderate, and high level of participation in physical activity according to the guidelines for the International Physical Activity Questionnaire Short Form, where a moderate to high level of participation is regarded as health-enhancing (more information on the questionnaire is available at www.ipaq.ki.se).

To assess cardiorespiratory endurance, the 6MWT[40] and a stair test[14] were used. The 6MWT is described as a simple and inexpensive walk test and can be used as a predictor of aerobic capacity.[12] Participants were instructed to walk as fast as possible (without running) back and forth between 2 cones on a flat, hard surface for 6 minutes.[40] With no significant difference between walking courses of 15 to 50m,[41] a distance of 15m between the 2 cones was used to be applicable in a clinical outpatient setting. The walking distance was measured in meters. The stair test is described as a submaximal cardiopulmonary exercise test.[14] We used a revised version of the stair test; for practical reasons we used the staircases available at each test location. All participants were instructed to ascend and descend 18 average-sized steps (17±1cm) 3 consecutive times. All the stairs comprised a platform (or repos) in-between the steps, implying that the participants had to take an additional step on level ground before continuing the steps. Participants were instructed to use all steps, they were allowed to run, and for safety reasons they could use the bannister if needed. The results were measured in seconds. Heart rate was recorded after both the 6MWT and stair test using a heart rate monitor.[a] Perceived exertion was measured after the 6MWT with Borg's rating of perceived exertion, which is a 15-point scale ranging from 6 (very, very light) to 20 (very, very hard).[42]

Muscle strength was assessed with a handgrip test[19] and the 30sSTS.[16] The handgrip test is a simple method of assessing muscle strength in the upper extremities.[19] The grip strength was measured using a hydraulic hand dynamometer[b] with 5 handle positions; the second position was used for all participants.[43] The testing was conducted with the participant seated with the upper arm alongside the trunk and the elbow at 90° of flexion. The dominant hand was tested first, and the mean of 2 trials was used in the analysis of the right and left hand. The 30sSTS is a measure of lower extremity strength.[11,44] Starting from a seated position with arms folded across the chest, the participants were instructed to complete as many full stands as possible in 30 seconds.[16] For practical reasons, chairs available at the different test locations were used, but all chairs were of standard height (44−45cm). The number of full stands was recorded.

List of abbreviations:

BMI	**body mass index**
FTF	**fingertip-to-floor test**
MSC	**musculoskeletal condition**
6MWT	**6-minute walk test**
30sSTS	**30-second sit-to-stand test**