ORIGINAL ARTICLE

Validity and Reliability of the Modified Shuttle Walk Test in Patients With Chronic Obstructive Pulmonary Disease

Loredana A. Campo, BScN, BScPT, DipMgmt, Pht, Gevorg Chilingaryan, DMD, MPH, Katherine Berg, PhD, Bruno Paradis, MD, Barbara Mazer, PhD

ABSTRACT. Campo LA, Chilingaryan G, Berg K, Paradis, B, Mazer B. Validity and reliability of the modified shuttle walk test in patients with chronic obstructive pulmonary disease. Arch Phys Med Rehabil 2006;87:918-22.

Objectives: (1) To examine the concurrent criterion validity of the modified shuttle walk test (MSWT) by using the 6- (6MWT) and 12-minute walk test (12MWT), (2) to examine the concurrent criterion validity of the estimated maximum oxygen uptake ($\dot{V}O_2$max) of the MSWT with actual $\dot{V}O_2$max, and (3) to determine test-retest reliability of the MSWT in patients with chronic obstructive pulmonary disease (COPD).

Design: Validation study.

Setting: Outpatient pulmonary rehabilitation program.

Participants: Thirty clinically stable adults with COPD.

Interventions: Not applicable.

Main Outcome Measures: Subjects were randomly assigned to receive either the 6MWT and 12MWT or the MSWT first. The MSWT was repeated 1 week later (N=30). Estimated $\dot{V}O_2$max was calculated, and actual $\dot{V}O_2$max was conducted by using the Jones test. Validity of the MSWT was assessed by comparing endurance scores and $\dot{V}O_2$max with results from the 6MWT and 12MWT and Jones test, respectively.

Results: There was a moderately high correlation between the MSWT and the 6MWT and 12MWT at initial testing (.82 and .74, respectively). Correlation between estimated and actual $\dot{V}O_2$max was *r* equal to .68. Test-retest reliability for the entire sample was high (intraclass correlation coefficient, .88). Results remained quite stable across severity, age, and sex subgroups.

Conclusions: The MSWT is a standardized externally paced submaximal endurance walking test. The results indicate that the MSWT has high concurrent validity and test-retest reliability for patients with COPD.

Key Words: Exercise; Maximal breathing capacity; Physical endurance; Pulmonary disease, chronic obstructive; Rehabilitation; Walking.

CHRONIC OBSTRUCTIVE Pulmonary Disease (COPD) is a progressive condition characterized by chronic airflow limitation that is not fully reversible and is associated with an inflammatory process in the lungs.[1] The worldwide prevalence of COPD in 1990 was estimated to be 9.34 in 1000 for men and 7.33 in 1000 for women,[1] with morbidity increasing with age. COPD is presently the fourth leading cause of death in the world,[2] and the burden of the disease is on the rise. In the United States in 2002, direct and indirect costs attributed to COPD were $18.0 and $14.1 billion, respectively.[3] More specifically, in the United States, 12.1 million adults aged 25 years and older were diagnosed with COPD in 2001, whereas epidemiologic evidence suggests that approximately 24 million adults actually have COPD, rendering the disease underdiagnosed.[3]

Deconditioning arises with chronic dyspnea because of decreased exercise tolerance and sedentarism,[1] and the reverse is also true. Clinical field tests of walking endurance are therefore of utmost importance in quantifying disability with this clientele. A variety of submaximal exercise walking tests that measure distance exist to predict maximum oxygen consumption ($\dot{V}O_2$max), and hence maximum aerobic power,[4] such as the 2- (2MWT), 4- (4MWT), 6- (6MWT), and 12-minute walk tests (12MWT) and the shuttle walk test, to name a few. These tests are valuable to help diagnose exercise intolerance, assess functional limitations, evaluate the outcomes of exercise programs, measure the effects of pharmacologic agents, and assess the recovery strategies on exercise performance.[5-8] To increase the validity and reliability of the data obtained, clinicians are advised to follow the prescribed methods of administration to insure accurate test performance and to use a number of physiologic measures such as heart rate, blood pressure, rate of perceived exertion, pain, and dyspnea to safely monitor patients.[4] Clinical submaximal exercise tests have long been favored over maximal exercise tests because some patients are unable to attain $\dot{V}O_2$max without fatiguing first or being limited by musculoskeletal, cardiopulmonary, or neuromuscular impairments.[4] Also, clinical submaximal tests have as advantages that they do not require the physician's presence, are more comfortable to undergo, are easier to administer (because little equipment is required), and more closely resemble exercise training conditions.

One of the most commonly used submaximal exercise tests is to determine a COPD patient's functional capacity[9] is the 12MWT. This test evolved from the 12-minute running test designed by Cooper[10] in 1968 and was adapted by McGavin et al[11] to a walking test as a means of estimating exercise tolerance in patients with chronic bronchitis. A previous study[9] showed that changes in $\dot{V}O_2$ per kilogram were more closely associated with changes measured by the 12MWT compared with changes in the 6MWT, 4MWT, or 2MWT, suggesting that

From the Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain, Jewish Rehabilitation Hospital, Laval, QC, Canada (Campo, Chilingaryan, Berg, Paradis, Mazer); Department of Physical Therapy, University of Toronto, Toronto, ON, Canada (Berg); School of Physical & Occupational Therapy, McGill University, Montreal, QC, Canada (Campo, Mazer); Cité de la Santé Hospital, Laval, QC, Canada (Paradis); and Centre Hospitalier Ambulatoire Régional de Laval, Laval, QC, Canada (Paradis).

Supported by the Jewish Rehabilitation Hospital Foundation, Centre de Recherche Interdisciplinaire en Réadaptation du Montréal Métropolitain.

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the author(s) or upon any organization with which the author(s) is/are associated.

Reprint requests to Barbara Mazer, PhD, CRIR-Jewish Rehabilitation Hospital, 3205 Place Alton Goldbloom, Laval, QC H7V 1R2, Canada, e-mail: *Barbara.mazer@mcgill.ca.*

0003-9993/06/8707-10359$32.00/0
doi:10.1016/j.apmr.2006.03.005

the 12MWT is more accurate in detecting changes in exercise capabilities in patients with COPD. Currently, outside a research protocol, the 6MWT is more commonly used in clinical practice because this measure was used to test many groups, such as people with COPD, heart failure, fibromyalgia, and musculoskeletal and neurologic impairments.[12] It was also found to be another highly valid and reliable measure of functional capacity across patient populations.[12]

Recent literature has now focused on a new submaximal walking test for patients with COPD, the modified shuttle walk test (MSWT). The MSWT was derived from the 20-m shuttle walk test (20SWT). The 20SWT was designed to assess maximum aerobic power in children, adults attending fitness classes, and athletes participating in sports requiring constant starting and stopping.[4] This test is unique because it paces the person with the use of sound signals on a prerecorded audiocassette tape and is thus more objective than the traditional informal tests described previously.[10] The 20SWT, however, is not appropriate for the elderly and for those with physical disability because it requires patients to run over a 20-m course for a period of time (walking not allowed). This would clearly not be a reasonable request for the elderly or for those with physical disabilities. The 12-level MSWT is an endurance walking test of disability in patients with chronic airway obstruction that was developed by Singh et al.[13] This test requires patients to either walk or run (as able) as fast as they can and is conducted over a shorter 10-m course. This 15-level MSWT was developed and tested in adult cystic fibrosis (CF) patients[14] and in those with chronic airway obstruction.[13] Results indicated that the MSWT is highly reliable, repeatable, and sensitive in those with adult CF.[15] Although the 20SWT has been tested in patients with COPD,[16-18] the validity and reliability of the MSWT was not evaluated in patients of varied COPD disease severity. The MSWT is externally paced with the audiocassette and possibly more reproducible,[13,17] whereas the 6MWT and 12MWT are internally paced. Also, the MSWT is a progressive intensity field test that "eliminates the variable effects of motivation and encouragement seen in self-paced tests [such as the 6MWT and 12MWT], and thus more closely approximates the test protocols used in laboratory measures of $\dot{V}O_2$max than do standard walking tests."[12,13,17] Because of the MSWT's more objective approach, it is anticipated to obtain a more accurate estimate of maximal exercise capacity compared with the 6MWT and 12MWT.

The primary objectives of this study were (1) to examine the concurrent criterion validity of the MSWT (number of meters walked) with the number of meters walked on the 6MWT and 12MWT; (2) to examine the concurrent criterion validity of the MSWT (estimated $\dot{V}O_2$max calculated by using a validated regression equation) with the actual $\dot{V}O_2$max score obtained on the Jones stage 1 test; and (3) to determine the test-retest reliability of the MSWT in patients with COPD. The secondary objective of the study was to determine the validity and reliability of the MSWT for subgroups of subjects with COPD (severity of COPD, age, and sex).

METHODS

Participants

Adult subjects aged 50 to 85 years were recruited prospectively from a rehabilitation hospital outpatient COPD program. The admissibility criteria included clinically stable (<10% variation in forced expiratory volume in 1 second [FEV_1] from the best test during the past 6 months, with no overriding comorbidities such as severe coronary artery disease, osteoarthritis, or other neuromuscular impairments) and the ability to come to the hospital for 2 testing sessions. Subjects were monitored for their health status throughout the study by using the Health Questionnaire to ensure continued admissibility.

Procedures

This was a prospective cross-sectional study that was conducted between January 2003 and June 2004. The study was approved by the institution's research ethics board. COPD outpatients who embarked on a 10-week rehabilitation program at a rehabilitation hospital were screened by the program nurse for admissibility, and potential subjects received an information letter at the preadmission clinic. Consent was signed in the nurse's presence, and no incentive was given for participating. To eliminate the effect of order, subjects were randomly assigned to receive either the 6MWT and 12MWT or the MSWT first (both done on the same day) by using prepared envelopes. An inhalation therapist performed the spirometric measures of lung function, and a physiotherapist administered the 6MWT and 12MWT as well as the MSWT at the same time of day during regularly scheduled treatment times. Study subjects performed these tests in the place of a regular treatment session to avoid excessive fatigue. The spirometric tests (FEV_1) were performed in the pulmonary rehabilitation department, whereas the walking tests were performed in the corridor of a low-traffic area of the hospital. Both the MSWT and the 6MWT and 12MWT were administered according to recommended guidelines.[12,17,19]

For the 6MWT, subjects were instructed to walk end to end of a 20-m course in a quiet corridor, covering as much ground as possible for 6 minutes. Standardized encouragement[12] was given throughout the test. They were told that they may rest if they were too short of breath or too tired to continue but could resume walking when they were able. At the end of the 6-minute duration, subjects were told to stop. The distance walked and the number of rests were noted.[12] For the 12MWT, the same protocol described for the 6MWT was used, except that the test was of a 12-minute duration.[12] The MSWT was administered by performing a practice test and 1 actual trial. For both the 6MWT and the 12MWT, subjects underwent 1 practice test and 2 trials separated by a 10-minute rest period. The final score for each (6MWT, 12MWT) was the average of the 2 trials. Test-retest reliability data were obtained by repeating the MSWT 1 week after the initial test. Again, 1 practice test and 1 actual test were administered.[12,13] Before testing, subjects were asked to complete the Health Questionnaire to ensure that their clinical status had not changed, and, if stable, the spirometric test was repeated. Many subjects were tested during the same time period such that it was highly unlikely that the evaluators could remember the result of each subject's performance on the various tests.

Actual $\dot{V}O_2$max values were obtained directly from the Jones stage 1 bicycle exercise test, which was conducted by an inhalation therapist and supervised by a physician. The estimated $\dot{V}O_2$max results obtained from the MSWT were compared with the $\dot{V}O_2$max obtained through the Jones test. The interval between them was no more than 3 weeks to minimize the influence of a true change in clinical status on the comparison of scores. The physiotherapist administering the MSWT was unaware of the subjects' $\dot{V}O_2$max scores and 6MWT and 12MWT results and the findings from other clinical tests.

FEV_1 was measured to classify the patients' COPD severity (mild, moderate, severe, very severe) in accordance with the Global Initiative for Lung Disease,[1] which was performed by the pneumologist at preadmission clinic. In addition, clinical information was collected by using the following measures: the Borg rating of perceived exertion (RPE) scale,[20] a measure of perceived exertion; respiratory rate; oxygen saturation