ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2013;94:2227-33

ORIGINAL ARTICLE

The Six-Minute Walk Test Cannot Predict Peak Cardiopulmonary Fitness in Ambulatory Adolescents and Young Adults With Cerebral Palsy

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Abstract

Objectives: To determine whether the 6-minute walk test (6MWT) is predictive of peak oxygen consumption (Vo_2peak) and whether the 6MWT is a clinically applicable alternative to cardiopulmonary exercise testing (CPET) in ambulatory adolescents and young adults with cerebral palsy (CP).

Design: Cross-sectional.

Setting: University hospital and rehabilitation centers.

Participants: Adolescents and young adults with CP (N=41) classified in Gross Motor Function Classification System (GMFCS) level I or II.

Interventions: Not applicable.

Main Outcome Measures: The covered distance during 6 minutes was measured with a 6MWT. The Vo_2peak was obtained with CPET on a cycle ergometer.

Results: Univariate linear regression analysis was used to study the relationship between the outcomes of both tests. A multiple linear regression analysis was performed to determine whether Vo_2peak could be predicted by the 6MWT, sex, body mass, and GMFCS level. A significant relationship ($P<.01$) was found between the outcomes of the 6MWT and CPET, with an explained variance of 21%. The multiple linear regression analysis showed an explained variance of 58% and a standard error of estimate (SEE) corresponding to 18% of the mean Vo_2peak.

Conclusions: The 6MWT is poorly related to Vo_2peak in ambulatory adolescents and young adults with CP. Because of a high SEE, the multiple regression model did not allow for prediction of Vo_2peak from the 6MWT in ambulatory adolescents and young adults with CP.

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Physical fitness contributes to a healthy lifestyle in the general population[1] but is even more important in persons with cerebral palsy (CP) to optimize and maintain performance in daily life.[2] Nevertheless, physical fitness, among which cardiopulmonary fitness is a key component, is low in persons with CP[2-4] and deserves attention in rehabilitation medicine.

The criterion standard for measuring cardiopulmonary fitness is peak oxygen consumption (Vo_2peak) with cardiopulmonary exercise testing (CPET).[5] However, CPET is time-consuming and requires relatively expensive equipment and trained staff. Therefore, CPET measurements are not suitable for use in clinical practice[6] and CPET is likely to be limited to specialized centers for research purposes. Hence, simple, inexpensive, and submaximal exercise tests are advised to assess peak cardiopulmonary fitness in clinical practice.

This project is part of the Dutch Learn2Move research program and is supported by ZonMw (grant no. 89000002) and the Phelps Stichting (grant no. 2008039).

No commercial party having a direct financial interest in the results of the research supporting this article has conferred or will confer a benefit on the authors or on any organization with which the authors are associated.

The following members of the Learn2Move Research Group contributed to this study: J. van Meeteren, MD, PhD, Department of Rehabilitation Medicine and Physical Therapy, Erasmus MC, University Medical Center, Rotterdam; W. van der Slot, MD, Rijndam Rehabilitation Center, Rotterdam; F. van Markus, MD, Sophia Rehabilitation, The Hague; A. Wensink-Boonstra, MD, Rehabilitation Center De Hoogstraat, Utrecht; and the Association of Physically Disabled Persons and their Parents (BOSK).

Clinical Trial Registration No.: NTR1785.

0003-9993/13/$36 - see front matter © 2013 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2013.05.023

The 6-minute walk test (6MWT) is a simple and submaximal exercise test in which the distance walked in 6 minutes under controlled conditions is measured.[7] Moderate to strong relationships between 6MWT distance and Vo_2peak have been shown in persons with cardiopulmonary disease,[8] heart failure,[9,10] and traumatic brain injury,[11] with correlation coefficients ranging from .58 to .73. Estimation of Vo_2peak is possible from 6MWT distance for persons with cardiopulmonary disease or heart failure, with a relatively small standard error of estimate (SEE).[12] The authors concluded that the 6MWT is an inexpensive and suitable alternative to CPET for these clinical populations.

The 6MWT has also been used as a surrogate measure of cardiopulmonary fitness in persons with CP.[13-15] In addition, a Delphi study,[16] which proposed a core set of exercise tests for children and adolescents with CP, advised using the 6MWT as a submaximal exercise test because the test seems to correspond to functional activities performed in daily life. To our knowledge, only 1 study[15] assessed the relationship between the 6MWT and Vo_2peak in persons with CP. The authors concluded that the 6MWT is a valid test for estimating Vo_2peak. However, given the low peak heart rates during CPET in that study, it is unlikely that (near) maximal exercise was achieved. Their results indicate that both the 6MWT and cycle ergometry were performed at submaximal exercise levels, which does not support the conclusion that the 6MWT is a valid test for estimating Vo_2peak.[17]

In a CP population, several factors may influence the 6MWT distance. Walking capacity can be decreased because of gait abnormalities[18,19] caused by spasticity, impaired balance, and reduced muscle strength.[19-22] These factors may decrease walking speed[23] during the 6MWT. In a study[24] on the relation between Vo_2peak and 6MWT outcome in patients with stroke, the authors concluded that the 6MWT outcome appeared to be more strongly influenced by potential limits to walking speed rather than cardiopulmonary fitness. Because of walking disabilities, this might also be the case in persons with CP, and therefore it is unclear whether the 6MWT can be used as a surrogate measure of cardiopulmonary fitness in persons with CP.

As exercise training becomes recognized as an integral component of rehabilitation programs for persons with CP, the aim of this study was to explore whether the 6MWT is a suitable alternative to CPET. Specifically, the study was designed to examine (1) whether 6MWT distance is related to Vo_2peak, and (2) whether 6MWT distance is predictive of Vo_2peak in ambulatory adolescents and young adults with CP.

Methods

Participants

Eligible participants were recruited from 6 rehabilitation centers and rehabilitation departments at university hospitals throughout the western and central regions of The Netherlands, and by the Association of Physically Disabled Persons and their Parents. Adolescents and young adults with unilateral or bilateral CP were eligible if they met each of the following inclusion criteria: (1) age 16 to 24 years; (2) Gross Motor Function Classification System[25] (GMFCS) level I to II; and (3) had a spastic type of CP as measured with the Modified Ashworth Scale.[26] Persons were excluded if they had any of the following: (1) disabilities other than CP that affected physical activity or peak cardiopulmonary fitness; (2) contraindication to (maximal) exercise; or (3) severe cognitive disorders or insufficient comprehension of the Dutch language to preclude understanding of the purpose of the project and its testing methods. Patient records were screened in the participating centers, and an informational letter and invitation to participate was sent to eligible persons. A reminder letter was sent 4 weeks later to nonresponders. All participants provided written informed consent. The study was approved by the Medical Ethics Committee of the Erasmus Medical Center, and local approval was granted by all participating centers.

List of abbreviations:

CP	cerebral palsy
CPET	cardiopulmonary exercise testing
GMFCS	Gross Motor Function Classification System
SEE	standard error of estimate
6MWT	6-minute walk test
Vo_2peak	peak oxygen consumption

Procedure

This study is part of a longitudinal multicenter intervention study to encourage daily physical activity and improve peak cardiopulmonary fitness among adolescents and young adults with spastic CP.[13] The data were collected at 3 different collaborating centers using consistent testing protocols. Baseline measurements from the longitudinal study were used to perform analyses of the current study.

The 6MWT and CPET were performed sequentially in this order, separated by at least 2 hours of rest. All participants reported that they had sufficient rest before starting CPET. In addition to screening for exercise contraindications by a rehabilitation physician, all participants completed the Physical Activity Readiness Questionnaire[27] to ensure that there were no contraindications to CPET.

Six-minute walk test

Participants performed the 6MWT according to the method described by Guyatt et al.[7] Patients were instructed to walk, not run, as far as they could along a 30-m level surface track during a 6-minute period. At the end of each minute, participants were told the elapsed time and standardized encouragement was provided using the following phrases: "you are doing well" and "keep up the good work," as recommended by the American Thoracic Society 6MWT guidelines.[28] Patients were allowed to stop and rest during the test but were instructed to resume walking as soon as they felt able to do so. The 6MWT distance (in meters) was registered. Measured 6MWT distance was compared with normative values for healthy adults using the formula of Gibbons et al,[29] which includes participant characteristics (sex and age). Mean heart rate during the 6MWT was measured using a Polar S810 heart rate monitor.[a] Gas exchange was not measured during the 6MWT because this does not correspond to the execution of the 6MWT in clinical practice. The 6MWT has been found to be a reliable test in young adults and adults with CP.[30]

Cardiopulmonary exercise testing

The Vo_2peak was measured during a progressive ramp protocol on electronically braked cycle ergometers (Jaeger ER800[b] and