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ORIGINAL ARTICLES

Learning and Encouragement Effects on Six-Minute Walking Test in Children

Natalia Morales Mestre, PT[1,2], Nicolas Audag, PT[1,2,3], Gilles Caty, PhD, MD[2], and Gregory Reychler, PhD, PT[1,2,3,4]

Objectives To evaluate learning and encouragement effects on the 6-minute walk test in children between 6 and 12 years of age.

Study design Two 6-minute walk tests separated by a 10-minute resting period were performed by healthy children between 6 and 12 years of age to evaluate the learning (part 1) and encouragement effects (part 2; randomization with and without encouragement). Distance and cardiorespiratory variables were used as outcomes.

Results 148 children were recruited. The intraclass correlation coefficient estimates were 0.927 (95% CI, 0.893-0.951; part 1) and 0.844 (95% CI, 0.744-0.907; part 2). The test-retest agreement was verified for distance ($P = .679$) with a bias of 1.1 m (95% CI, −4 to 6), but the increase in distance with encouragement was significantly and clinically relevant ($P < .001$; +41 m; 95% CI, 33-50).

Conclusion No training is required for the 6-minute walk test in children, in contrast with adults, but there was an encouragement effect on the walked distance in these children. Guidelines should take these results into account. *(J Pediatr 2018;■■:■■-■■).*

Trial Registration ClinicalTrials.gov: NCT03276299.

The evaluation of functional exercise capacity is important in children with various diseases.[1-4] The 6-minute walk test is the criterion standard for this purpose and it has been regularly used in children.[5-7] The validity and reliability of this test have been verified in children.[8-12]

Performance on the 6-minute walk test in adults is influenced by many technical factors, such as instructions, location, path length, track layout, or walking aid.[13-17] Ethnicity is also considered as an influencing element.[18] A recent technical standard for adults was co-published by the European Respiratory Society and the American Thoracic Society.[19] Two of the influences on the 6-minute walk test were the learning and encouragement effects. Neither learning nor encouragement effect have been specifically evaluated in children, and children were not included in the international technical standard on standardization of this test.[19]

We hypothesized that these effects could be different in children under 12 years of age. Indeed, the intrinsic motivation that is related to these effects is different between adults and in children under 12 years of age.[20] The 6-minute walk test is a submaximal test[21] and probably easier for children than for adults. Moreover, time perception is underdeveloped in children.[22] Encouraging children during the test can be attractive to stimulate performance and could influence the results of the 6-minute walk test. An encouragement effect has been demonstrated in the intrinsic motivation of children.[23] The aim of this study was to verify the learning and encouragement effects on functional exercise performance in the 6-minute walk test in healthy children between 6 and 12 years of age.

Methods

Healthy children were recruited in a French-speaking Belgian elementary school between June 2015 and March 2016. The inclusion criteria were participation in the national physical education program at school after the annual medical investigation, Caucasian, and between 6 and 12 years old. The exclusion criteria were to have acute or chronic lung, cardiac, or neuromuscular disease, to be overweight (body mass index >85th percentile for children of the same age and sex),[24] and to have a cognitive disorder or a motor disability based on parent answer to a standardized questionnaire. The subjects were free of physical activity for 1 hour preceding the study. They participated only in 1 part of the study.

HR	Heart rate
ICC	Intraclass correlation coefficient

From the [1]Institute of Experimental and Clinical Research (IREC), Pole of Pulmonology, ORL & Dermatology, Catholic University of Louvain; [2]Department of Physical Medicine and Rehabilitation, Saint-Luc University Clinics; [3]Leonard de Vinci High School, Parnasse-Deux Alice; and [4]Pulmonology Unit, University Hospital Saint-Luc, Brussels, Belgium

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The study was approved by the regional Ethic Committee in Cliniques universitaires Saint-Luc and Université Catholique de Louvain in Brussels in 2015 (BE403201524763-BE403201524845) and registered with ClinicalTrials.gov (NCT03276299). Parents of the children and children provided their written informed consent before the experiment.

The study included 2 parts and 2 distinct samples of children were recruited. The children performed two 6-minute walk test in both parts of the study separated by a 10-minute resting period. In part 1, the 6-minute walk test was repeated twice under the same conditions to evaluate the learning effect. In part 2, a stimulating, standardized, and repetitive encouragement to maintain the same walking pace was randomly added to one of the tests (www.randomizer.org) to evaluate the encouragement effect.

All 6-minute walk tests were carried out in a straight, unobstructed, flat corridor using the protocol validated in healthy children by Li et al.[9] Children were instructed to walk as far as possible for 6 minutes between 2 marks separated by 30 m. During all tests, standardized sentences were pronounced to give time indications every minute. During the 6-minute walk test with encouragement, sentences such as "Just keep going," "It is good," "Continue like this," and "You are doing well" were played every 15 seconds. All tests were performed by a trained examiner, independent of the analysis.

Walking distance was measured as main outcome and expressed in absolute and in relative values based on Goemans' equation.[25] Measurements of oxygen saturation and heart rate (HR) were measured with a finger pulse oximeter (Onyx, Nonin, Plymouth, MN). Change in HR was calculated by the difference between initial and final values divided by the initial value. Dyspnea was evaluated through the visual analog scale at rest, immediately after the test and after a 2-minute recovery. Age, weight, and height were recorded.

Statistical Analyses

The sample size determination was based on the detection of a 0.70 correlation coefficient between 2 field tests with a power of 80% and an alpha level of 0.05. The number of participants required for the study was determined to be ≥52.

Data were computed using SPSS 24.0 (IBM software, Chicago, IL) for Windows. Descriptive analysis was performed for anthropometric variables and for results of both tests. Variables were presented as mean, SD, and CI, or median and minimum and maximum after verifying the normality of the distribution by Kolmogorov-Smirnov test. The variability was calculated by the coefficient of variation. Intraclass correlation coefficient (ICC) was calculated using a 2-way mixed effects model for absolute agreement from a single measurement to verify the learning effect and using a 2-way random effects model for absolute agreement from a single measurement to verify the encouragement effect. ICC was expressed by absolute value and 95% CI. Reliability was interpreted from the ICC as poor (ICC of <0.50), moderate (ICC from 0.50 to 0.75), good (ICC from 0.75 to 0.90), or excellent (ICC of >0.90).[26] Agreement between the first and second tests and between the tests with and without encouragement was calculated by paired Student *t* test and Bland-Altman method for distance and HR change. Bias (mean of the differences) and limits of agreement were calculated.[27] $P < .05$ was considered significant. When a difference between both tests was found, Pearson coefficient of correlation was calculated between age and changes in distance to verify the effect of age.

Results

One hundred two children were eligible, 2 declined to participate, and 5 were excluded (**Figure 1**, left) for musculoskeletal disorders (n = 2), acute rhinitis (n = 1), and overweight (n = 2). Ninety-five children were recruited. The sample to evaluate the learning effect included 57 girls and 38 boys. Both tests were performed by all the recruited children.

The results of both tests are presented in **Table I**. The mean walked distance corresponded to 93% of the predicted values. The ICC estimate was 0.927 (95% CI, 0.893-0.951; **Figure 2**, A, left). The test-retest agreement was verified for distance (537 ± 69 m vs 536 ± 67 m; $P = .679$; **Figure 2**, A, right). Bias was 1.1 m (95% CI, −4 to 6) and limits of agreement were −52 and +50 m. The coefficient of variation for the walked distance was similar in both tests (12.8% vs 12.5%). In contrast with distance, HR change showed a learning effect (33 ± 21% vs 28 ± 21%; $P = .011$). Bias was 5% (95% CI, −9 to −1) and limits of agreement were −44% and 34%.

Fifty-seven children were eligible and 53 were recruited (**Figure 1**, right). Four children were excluded for overweight (n = 2), broken foot (n = 1), and a cognitive disorder (n = 1). The sample to evaluate the encouragement effect included 30 girls and 23 boys. All recruited children performed both tests.

The results of both tests are presented in **Table II**. The ICC estimate was 0.844 (95% CI, 0.744-0.907; **Figure 2**, B, left). The distance increased when encouragement was given to the children (466 ± 58 m vs 507 ± 57 m; $P < .001$; **Figure 2**, B, right). The coefficients of variation were around 12% for both tests. Bias was 41 m (95% CI, 33-50) and limits of agreement were −22 and +105 m. The encouragement tended to increase the HR change even if it was not significant (25 ± 22% vs 32 ± 22%; $P = .07$). Bias was 7% (95% CI, −1 to 15) and limits of agreement were −48% and 62%. Age was not associated with the change in distance related to the encouragement (r = −0.196; $P = .160$).

Discussion

Repeatability and reliability are two of the fundamental properties of a test and are influenced by many factors. They represent the extent to which a test provides the same result on repeated testing occasions. The reproducibility of the 6-minute walk test has been evaluated in children in different studies with test–retest intervals varying from 4 days[28] to 4 weeks.[9] They showed intertest differences up to 15 m, but lower than the differences found in adults (>20 m) and highlighted the in-

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