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

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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

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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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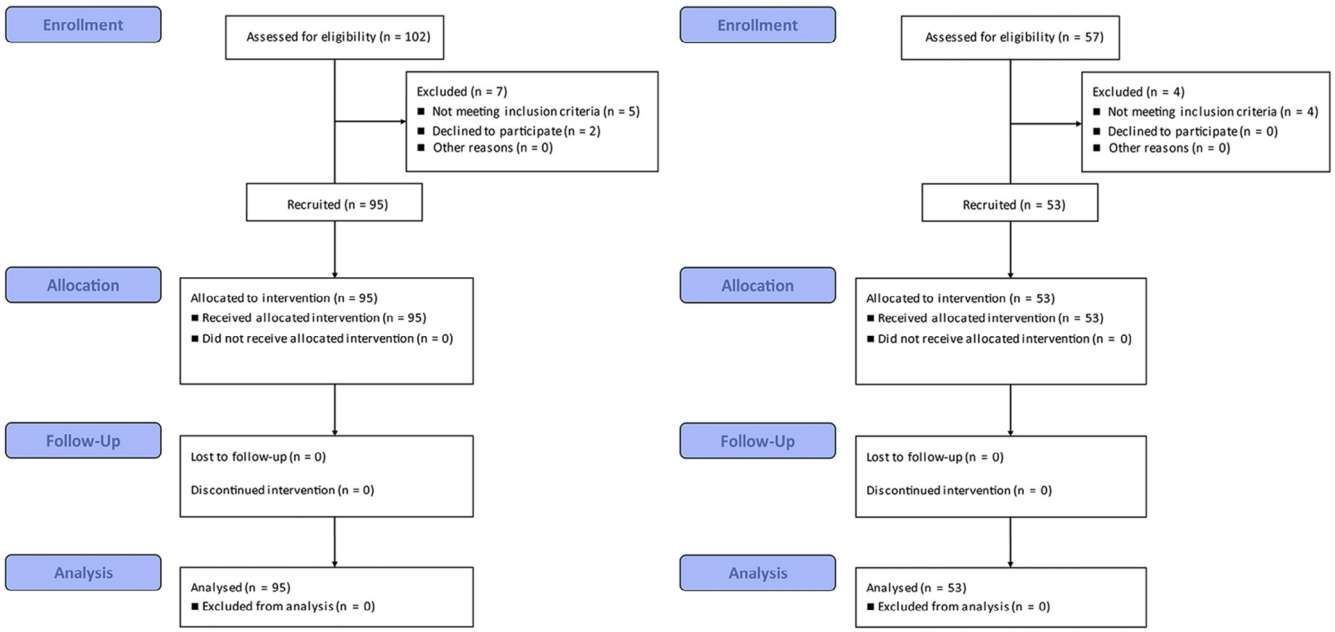

Figure 1. CONSORT flow chart of the both parts of the study (*left*, learning effect; *right*, encouragement effect).

fluence of the time on the result. Because of the time between tests, these studies cannot evaluate the learning effect. In contrast, the repeatability has been evaluated previously in children with chronic heart disease,[29] with cystic fibrosis,[6,10] and in healthy children.[29,30] The children in these studies were not representative due to small sample size (<30 children), heterogeneity of age (mean age of >10 years), inclusion criteria variability from the current guidelines for the 6-minute walk test, or the repetition of 2 tests by 2 evaluators.

Owing to the reliability (ICC of >0.90) and the agreement between both repetitions of the walked distance by children (around 1 m) found in our study, there may be no need to repeat this test in children, unlike what is required in adults.[18] There was no evidence for a learning effect for the 6-minute walk test in children <12 years of age. When the distance increases between 2 conditions or after a treatment, our results suggest it is not related to a learning effect and is likely due to the intervention.

However, if the evaluation of HR change during exercise is the main objective of the test, a learning effect would have to be taken into account. The observed change in HR is probably not clinically relevant. Because the HR was lower for a

Table I. Characteristics of the children and results of the 6-minute walk tests 1 and 2

Outcomes	6-Minute walk test 1 (n = 95)		6-Minute walk test 2 (n = 95)		*P* value
Age (y)	8.7 ± 19	8.3-9.1			
Weight (kg)	31.0 ± 7.9	29.4-32.6			
Height (cm)	131 ± 11	130-134			
BMI (kg/m^2)	17.6 ± 2.4	17.1-18.1			
Distance (m)	537 ± 70	523-551	536 ± 68	520-548	.679
Distance (% of predicted)	93 ± 11	90-95			
HR_i (bpm)	93 ± 12	91-96	96 ± 12	94-99	.010*
HR_f (bpm)	124 ± 19	120-128	122 ± 21	118-127	.347
HR_r (bpm)	94 ± 13	91-97	95 ± 14	93-98	.172
SpO_{2i} (%)	98 ± 1	99-99	99 ± 1	99-99	.123
SpO_{2f} (%)	99 ± 1	99-99	99 ± 1	99-99	.857
SpO_{2r} (%)	99 ± 1	99-99	99 ± 2	98-99	.188
$Dyspnea_i$ (/10)	0.3 ± 1	0.1-0.5	0.3 ± 0.6	0.1-0.4	.745
$Dyspnea_f$ (/10)	1.2 ± 1.6	0.8-1.5	1.1 ± 1.5	0.8-1.5	.858
$Dyspnea_r$ (/10)	0.6 ± 1.1	0.4-0.9	0.6 ± 1	0.4-0.8	.832
$Fatigue_i$ (/10)	0.8 ± 1.1	0.5-1.0	0.4 ± 0.7	0.2-0.5	.001*
$Fatigue_f$ (/10)	1.4 ± 1.4	1.2-1.7	1.3 ± 1.4	1-1.6	.202
$Fatigue_r$ (/10)	0.7 ± 1.1	0.5-0.9	0.7 ± 1.2	0.5-1.0	.863

BMI, Body mass index; *i*, initial; *f*, final; *r*, at rest; *SpO_2*, peripheral capillary oxygen saturation.
Data are expressed by the mean ± SD and 95% CI.
*Signifies $P < .05$.

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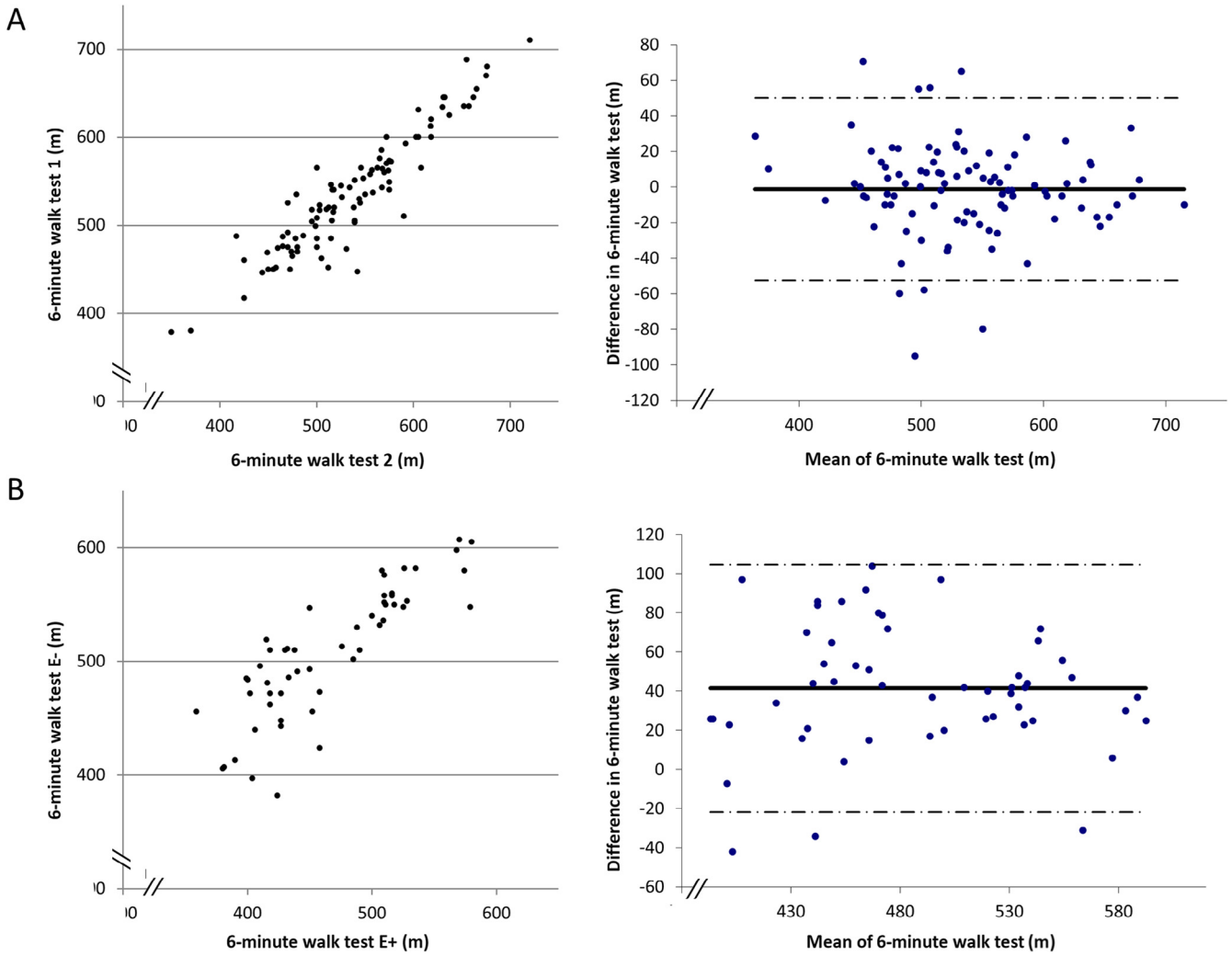

Figure 2. Relationship between **A,** first and second 6-minute walk test (*left*) and Bland-Altman plots for distance between these tests (*right*) and **B,** between 6-minute walk test with and without encouragement (*left*) and Bland-Altman plots for distance between these tests (*right*).

Table II. Characteristics of the children and results of the 6-minute walk test

	6-Minute walk test E– (n = 53)		6-Minute walk test E + (n = 53)		*P* value
Age (y)	8.9 ± 2.1	8.4-9.5			
Weight (kg)	34.9 ± 11.3	31.8-38.0			
Height (cm)	137 ± 15	134-142			
BMI (kg/m^2)	17.9 ± 3.1	17.1-18.8			
Distance (m)	466 ± 59	450-482	507 ± 57	491-523	<.001*
HR_i (bpm)	95 ± 15	91-100	94 ± 14	90-98	.616
HR_f (bpm)	117 ± 15	113-121	123 ± 15	118-127	.031*
HR_r (bpm)	100 ± 13	96-104	98 ± 15	94-102	.434
SpO_{2i} (%)	99 ± 1	98-99	99 ± 1	99-99	.020*
SpO_{2f} (%)	98 ± 2	98-99	98 ± 1	94-102	.764
SpO_{2r} (%)	99 ± 1	98; 99	99 ± 1	99-99	.177
$Dyspnea_i$ (/10)	.0 ± 0.1	0.0-0.1	.0 ± 0.1	0.0-0.1	.322
$Dyspnea_f$ (/10)	2.2 ± 0.7	2.0-2.4	2.3 ± 0.7	2.1-2.5	.348
$Dyspnea_r$ (/10)	1.2 ± 0.4	1.1-1.3	1.1 ± 0.2	1.0-1.1	.033*

E+, with encouragement; *E–*, without encouragement.
Data are expressed by the mean ± SD and 95% CI.
*$P < .05$.

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Table III. Test-retest differences found in children in the previously published studies

Authors	Year	Interval	n and disease	Age	6-Minute walk distance 1 (m)	6-Minute walk distance 2 (m)	Bias (m)	ICC
Cunha et al[6]	2006	30 min to 12 h	16, CF	11	582	598	−15.9	NA
Li et al[9]	2005	2 to 4 wk	52, healthy	14	622	677	15	0.94
Gulmans et al[10]	1996	1 wk	23, CF	11	737	742	NA	0.90 (r)
Martins et al[30]	2014	30 min	29, healthy	10.5	570	564	5.5	0.742
Moalla et al[29]	2005	<12 h	14, healthy	13	549	NA	−1.4	NA
Moalla et al[29]	2005	<12 h	17, CHD	13.5	473	NA	−1.3	NA
Morinder et al[28]	2009	4 d	49, obese	13	571	574	2.8	0.84

CF, Cystic fibrosis; *CHD*, chronic heart disease; *NA*, not available.

similar walked distance, we hypothesize that the test was less stressful. It could be explained by a training effect or a better effort management by the children with benefit on the cardiorespiratory demand.

Encouragement has been demonstrated to improve endurance performance.[31] For such a long duration as for the 6-minute walk test, the time perception could be more difficult in children and encouragement is sometimes used to maintain attention during such a task.

It is useful to evaluate encouragement in children. First, most children fail to demonstrate consistent accuracy at judging relative durations before age of 11 or 12 years,[32] especially for tasks with a longer duration.[33] Second, intrinsic motivation varies with age increasing until 15 years of age and stabilizes after this age.[20]

Although the reliability between the tests was good, an improvement in walked distance related to encouragement was observed in our study. This improvement was greater in children than reported in adults (40 m vs 30 m).[34] The variability of walked distance was not influenced by encouragement. Indeed, there was no difference in the coefficient of variation when encouragement was given to the children. Moreover, there was no correlation between age and the improvement. Both findings suggest that the effect was similar for all children.

Because the absence of learning effect was demonstrated in the first part of the study, we postulate that the observed improvement is only explained by encouragement. Thus, the effect of encouragement must be taken in account in children, similar to in adults, because the improvement was twice as high as the smallest bias found in the studies of reproducibility (**Table III**) and 40 times higher than the bias related to the repeatability of the test.

Some limitations need to be addressed to the study. First, only healthy subjects were recruited. It could be argued that, in contrast with healthy subjects in our study, patients could walk a shorter distance in the second 6-minute walk test owing to fatigue related to the disease. This phenomenon was not observed in the studies comparing the reproducibility in walking tests between healthy subjects and patients.[29] Moreover, the longer distance observed in the second 6-minute walk test in patients with cystic fibrosis does not suggest this effect, despite patients having potentially greater physical limitations.[6] Second, the 10-minute interval for resting between both tests could be too short to complete the recovery in patients with cardiorespiratory diseases. In patients with chronic obstructive pulmonary disease, the variability was more pronounced when repeated walks were performed over short intervals.[35] In our healthy subjects, we postulate that this interval was sufficient, as illustrated by the similar initial heart and respiratory rate at the initial evaluation of both tests. That factor should be examined in a different population of patients.

We showed that no training was required for the 6-minute walk test in children, in contrast with adults, but there was an encouragement effect on the walked distance during the test in these children. Further guidelines should take into account these results in children under 12 years of age to standardize the use of encouragement during the 6-minute walk test in this population. ■

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