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Test–retest reliability and developmental evolution of the 6-min walk test in Caucasian boys aged 5–12 years

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Abstract

The 6 min walk test (6MWT) assesses functional capacity and has been used as outcome measure in therapeutic studies in childhood neuromuscular disorders. The objectives were to evaluate test–retest reliability of the 6MWT and to generate normative data for healthy boys aged 5–12 years. Ninety boys (mean age 8 years 10 months) were recruited over four age subcategories (5–6, 7–8, 9–10, 11–12 years). Mean 6MWT distance and velocity (±standard deviation) for the total group were 555.5 ± 93 m and 92.6 ± 16.6 m/min. The 6MWT distance increased significantly with age. Test–retest reliability (mean interval 12 days) was very high for the total group (ICC > 0.95) and for all age subcategories (ICC > 0.80) a moderately high reliability (ICC > 0.75) was found from 3 min onwards for each age subcategory. There was a mean difference of 5.2 m between test and retest without systematic bias. The standard error of measurement and smallest detectable difference were 20.7 and 57.4 m, respectively. These findings demonstrate the reliability of the 6MWT in young children, underscore its evolution with age, and indicate that a shorter version of the test is also reliable.

Keywords: 6-min walk test; Healthy children; Reliability; Reference data; Exercise capacity; Duchenne muscular dystrophy

1. Introduction

The 6-min walk test (6MWT) measures the distance (6MWD) a subject is able to walk on a flat surface in 6 min, and is a method to assess functional exercise capacity at submaximal level. The test has been used in the assessment of physical capability and walking function of subjects with cardiac, pulmonary, neurological and musculoskeletal disorders, and has been shown to be an independent predictor of morbidity and mortality in certain chronic cardiovascular or pulmonary diseases [1–5]. Furthermore, it has been used as a (primary) endpoint for ambulatory function in registration directed therapeutic studies in neuromuscular and metabolic disorders [6,7].

More recently, a modified 6MWT has been validated in children with Duchenne muscular dystrophy (DMD), an X linked disorder characterized by progressive muscle weakness, loss of ambulation and progressive cardiorespiratory impairment [8]. The modifications involved standardized instructions to the children prior to the testing, as well as a "safety chaser" and standardized verbal encouragement for maintained motivation during the test. A study in a small sample of DMD patients suggested that this modified 6MWT is feasible, reproducible and sensitive to change [9]. Being considered as clinically meaningful it has been increasingly used in natural history studies and as (primary) outcome measure in therapeutic trials in ambulatory boys with DMD.

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However, while different studies have reported measured values for the 6MWT in healthy children from different ethnic, environmental and geographical backgrounds [10–17] data on the reliability of the 6MWT in young children are scarce [8,14,18,19]. For healthy children, data are limited to the age range 12–16 years [14], whereas the reliability in younger children has only been studied in a small sample of DMD patients [8]. Concerns exist on a possible impact of motivational and developmental aspects on performance and hence reliability of the test in young children. The age group 5–12 years is of particular interest in relation to natural history studies and clinical trials in the ambulatory phase of DMD, underscoring the need for more profound insights into the reliability of the 6MWT and the developmental evolution of the 6MWD in this young age range.

The aims of this study were to investigate the test–retest reliability of the modified 6MWT [9] in a large cohort of typically developing healthy boys aged 5–12 years and in narrow age subcategories, to further generate normative data for this young age group, and to assess the correlation of 6MWD with anthropometric characteristics.

2. Materials and methods

2.1. Participants

Typically developing Caucasian boys were recruited from randomly selected local primary schools between March 2010 and February 2011. They were included if they were aged 5–12 years and sampled across four age subcategories: 5–6, 7–8, 9–10 and 11–12 years. Children had to be able to understand and fully comply with 6MWT assessment. Children with health related problems (such as neurological, cardiovascular, respiratory or musculoskeletal disorders) were excluded. Mild developmental problems, such as attention deficit disorders or learning difficulties, were not excluded. Ethical approval to collect 6MWD in healthy boys was obtained from the institutional committee and from the institutional boards of the local participating schools. The parents of all children gave their written informed consent.

2.2. Assessment

Participants weight, standing height and leg length were measured using standard anthropometric methods. The 6MWT as described by McDonald [9] was performed indoors at the school, along a flat straight corridor. Each boy walked 6 min (timed with stopwatch) along a 25 m tape line, with cones placed at each end of the course and marks to show the path to follow. Total distance as well as minute split distance were recorded. At the beginning of the test, the boys were instructed to walk up and down along the tape line and the marks around the cones, at their preferred pace, but not to run or jog. Evaluators gave a standard demonstration prior to the test and each boy did one practice trial over one track length to ensure that the child understood the instructions. During the test, the boy was followed by a "safety chaser" giving limited, standardized encouragements each time the boy was at a cone.

2.3. Reliability assessment

All children were tested twice by one of three clinical evaluators, with a test–retest interval of approximately two weeks. A detailed instruction manual was developed and the three evaluators practiced jointly to standardize the test procedure. In each participant the test and retest was performed by the same evaluator.

2.4. Statistical analysis

Descriptive statistics were used to document general and clinical characteristics. Test–retest reliability was assessed for the distance walked after 6 min and after each minute, for the total group and the four age subcategories. Intraclass correlation coefficient (ICC) and 95% confidence intervals (CI) were used. ICC values above 0.80 were considered as very high, between 0.60 and 0.79 as moderately high, between 0.40 and 0.59 as moderate, and less than 0.40 as low [20]. Furthermore, the standard error of measurement (SEM) and smallest detectable difference (SDD) were calculated for the 6MWD using following formulae: $SEM = SD \times \sqrt{(1-ICC)}$, and $SDD = SEM \times 1.96 \times \sqrt{2}$ [21]. The consistency of test–retest measurements was examined using the method of Bland and Altman [22]. Differences in 6MWD between the four age categories were determined via one-way analysis of variance (ANOVA), with post–hoc Tukey's studentized range tests. To investigate the relationship between age, anthropometric variables and 6MWD, correlation and multiple regression analyses were performed. Pearson's product moment correlation coefficients (r) were applied. Correlation coefficients >0.70 were considered as high, 0.50–0.70 as good, 0.30–0.50 as fair and <0.30 weak or no association [23]. A forward multiple regression analysis was then performed with the 6MWD as dependent variable and age, leg length, height and weight as predictor variables. The level of significance was set at 0.05. Statistical analyses were conducted with SAS Enterprise guide 4.1 (SAS Institute, Inc., Cary, NC).

3. Results

3.1. Participant characteristics

A total of 90 boys were recruited. All participants were from Caucasian origin. The mean age of the total group ($N = 90$) was 8 years and 10 months, standard deviation (SD) of 2 years and 3 months. Anthropometric data are reported in Table 1.

3.2. Test–retest reliability

Mean test–retest interval was 12 days, ranging 10–17 days. The ICCs with CI between test and retest are