RESEARCH ARTICLE

Assessment of functional ability by anthropometric and physiological parameters during six-minute walk test in healthy children

Maria Khalid[1], Hafsah Arshad[2], Sania Khawar Kiyani[3], Fouzia Batool[4], Zainab Saad[5], Aleena Hameed[6]

Abstract

Objective: To assess the functional ability and vitals of young children using six-minute walk test.

Method: The analytical cross-sectional study was conducted from October 2019 to January 2020 at public and private schools of Rawalpindi and Islamabad after approval from the ethics review committee of Riphah College of Rehabilitation Sciences, Westridge Campus Rawalpindi, Pakistan, and comprised healthy children aged 7-12 years who were subjected to the six-minute walk test according to standardised guidelines. Data was collected using a semi-structured questionnaire. Anthropometric measurements, distance walked in six minutes, heart rate, respiratory rate, oxygen saturation, and rate of perceived exertion were the outcome variables. Data was analysed using SPSS 26.

Results: Of the 376 subjects, 225(59.8%) were boys and 151(40.2%) were girls. The mean age of the sample was 9.25±1.64 years. Mean distance covered by the children was 482.63±119.76 metres. Public school students performed better than those studying in private schools (p=0.001). The difference in gender terms was non-significant (p=0.926). Significant difference was observed in mean heart rate and respiratory rate post-walk (p<0.05). There was a weak positive correlation of the test with age and height (p<0.001), but not with weight, gender and body mass index (p>0.05).

Conclusion: The level of functional ability of the young students improved with age and was better among those studying at public schools. Besides, anthropometric and physiological parameters influenced the text performance.

Keywords: Children, Six-minute walk test, Heart rate, Perceived exertion. (JPMA 72: 1783; 2022)

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Introduction

Functional health status is defined as the ability to perform activities of daily living (ADL), which are vital to meet the psychological, physical and social needs. Four different domains are assessed for the purpose; functional reserve capacity, functional performance, functional utilisation capacity and functional ability or capacity.[1]

Functional ability or capacity can be defined as individual's maximum potential to perform ADLs that require continuous aerobic metabolism.[2]

A wide variety of tests can be conducted to access the functional ability of children, including Sit to Stand Test (SST), the stepping test (ST) and the Six-Minute Walk Test (6MWT).[1] The 6MWT is submaximal exercise test widely used in clinical settings to measure the distance covered in a time span of six minutes. It was established by the American Thoracic Society (ATS) and was presented in 2002.[3] Previous studies reported 6MWT as a simple, valid, practical and reliable measure of submaximal exercise capacity in healthy children.[4,5] It also covers children with chronic diseases or musculoskeletal disorders (MSDs) which include juvenile idiopathic arthritis, cerebral palsy (CP), end-stage renal disease (ESRD), cystic fibrosis , spina bifida, acute brain injuries, cardiopulmonary disease, and children with heart and lung transplants.[6-11] It is also considered low-cost, standardised, safe and can be administered with minimal equipment, training and in less time, and is more reflective of ADLs than the other walk tests. Literature reported technical factors which can influence 6MWT, including location, guidelines and instructions that are given to students, length of the corridor or path, track layout, surface type walking aid and ethnicity.[12] The 6MWT gives beneficial information related to blood pressure (BP), heart rate (HR) and arterial oxygen saturation (SaO_2) levels.[13] Studies found 6MWT conducted from pre-school children aged 2-5 years to the elderly aged >65 years.[14] The test-retest reliability of 6MWT in the healthy children and in adolescents is high, ranging between intraclass correlation coefficient (ICC) 0.74 in those aged 6-12 years, and ICC 0.80 in those aged 5-6 years to ICC 0.94 in those aged 11-12 and 12-16 years.[15] Several studies have reported reference values for 6MWT for healthy children and adolescents,[1,216-19] while others have reported the association of obesity with 6MWT.[13,18,20,21]

The current study was planned to determine the functional ability and vitals of young children using 6MWT.

[1,3]Department of Rehabilitation and Allied Health Sciences, Riphah International University, Westridge campus, Rawalpindi, Pakistan; [2]University Institute of Physical Therapy, University of Lahore, Islamabad Campus, Pakistan; [4]Department of Rehabilitation Sciences, Shifa Tameer-e-Millat University, Islamabad, Pakistan; [5]Safari Hospital Bahria Town, Rawalpindi, Pakistan; [6]Department of Rehabilitation, Cleft Hospital, Gujrat, Pakistan.
Correspondence: Maria Khalid. e-mail: maria.khalid@riphah.edu.pk

Subjects and Methods

The analytical cross-sectional study was conducted from October 2019 to January 2020 at public and private schools of Rawalpindi and Islamabad, Pakistan. After approval from the ethics review committee of Riphah College of Rehabilitation Sciences, Westridge Campus Rawalpindi , Pakistan, the sample size was calculated using Epitool calculator[22] while assuming student population to be 20,000 and estimated proportion 0.525 at 95% confidence level and 5% margin of error.[16] The sample was raised using non-probability convenience sampling technique from among healthy students aged 7-12 years from the participating schools. The participating public and private schools were: the Government New Islamia Model Secondary School, Carriage Factory, Rawalpindi; the Federal Government Public School, Rawalpindi; the Islamabad Model School (girls and boys campuses), Islamabad; the Siddiq Public School, Rawalpindi; the Dar-e-Arqam School, Rawalpindi and Islamabad campuses; the Allied School Main Campus, Rawalpindi; The Educators, Satellite Town Campus; The City School, Islamabad; and the Al-Syed Model School, Islamabad. Children having cardiovascular, congenital heart deficits, respiratory problems, including asthma, or congenital diseases and hypertension, neuromuscular or MSD that interfere with walk, history of hospital stay in the receding three months, lower limb fracture, fever or history of common cold or flu within the preceding four weeks, long-term medication that may interfere with the walk test were excluded. Written informed permission and consent were taken from the school principals and the participants.

Data was collected using a semi-structured questionnaire that has a Cronbach's alpha value of 0.84. Height and weight of the participants were measured, and body mass index (BMI) was calculated using the standard formula. Functional mobility was assessed with 6MWT. Heart rate (HR) in beats per minute, respiratory rate (RR) in breaths per minute, and saturation of peripheral oxygen (SPO_2) (%) was measured using pulse oximeter (Certeza PO 910). Modified Rate of Perceived Exertion (RPE) scale was used to check level of exertion. All readings were taken before and after the 6MWT administration.

The 6MWT was administered according to the protocol of the American Thoracic Society (ATS).[23] An internal hallway with 100-foot distance was marked by coloured tape on the floor. Children were instructed to walk for six minutes within the marked area. Before conducting the test, the participants were guided to avoid heavy meals. There was no warmup, but the subjects were allowed to rest by sitting on a chair at the starting point for 10 minutes before the commencement of test. During this time, resting HR, RR, SPO_2 and RPE readings were taken. The children were instructed that the goal was to walk as far as possible in six minutes without doing any exertional activity, like brisk walking, running or jogging. The students were verbally motivated by a single researcher at preset times during the test. At the end of six minutes, noted with the help of a stopwatch, the participants were asked to stop, and the distance covered in meters was recorded.[24] Post-test vitals and RPE score were recorded for each participant. No repeat test was conducted.

Data was analysed using SPSS 26. Descriptive analysis was done for demographic characteristics. Normality of all variables were assessed using Shapiro-Wilk test, and normality plots, curves, symmetry, kurtosis, and histogram distribution were inspected. The skewness and kurtosis ranged from-1 to +1 and -2 to +2, respectively. Normally distributed data was presented as mean±standard deviation. For inferential analysis, independent t-test was conducted to compare mean values, and paired sample t-test was applied on HR, RR, SPO_2 and RPE to analyse significant difference between the mean values of pre- and post-6MWT. Pearson product-moment correlation coefficient was used to examine associations between age, gender, height, weight and BMI. All analyses performed were 2-tailed, with $p<0.05$ with 95% confidence interval (CI) being statistically significant.

Results

Of the 376 subjects, 225(59.8%) were boys and 151(40.2%) were girls. The mean age of the sample was 9.25±1.64 years. Overall, 167(44.4%) students were from public and 209(55.6%) from private schools. In terms of age, 75(19.9%) students were aged 7 years, 66(17.6%) aged 8 years, 62(16.5%) aged 9 years, 79(21%) aged 10 years, 50(13.3%) aged 11 years, and 44(11.7 %) were aged 12 years. The mean BMI of the sample was 15.92±3.49kg/m^2. Public school students performed better than those studying in private schools (Table 1).

Mean distance covered by the children was 482.63±119.76 metres (range: 304.80-838.20 metres). The distance increased with age and reached the maximum mean of 519.53±115.95 metres at age 11 years (Table 2).

The difference in gender terms was non-significant ($p=0.926$). Most of boys 54(14.4%) covered distance 501-600m, 35(9.3%) covered 601-700m, 8(2.1%) covered 701-800m, and 3(0.8%) covered 801-900m. Among the girls, none of participants covered distance beyond 700m. Among public school students, 81(21.5%) and 57(15.2%) covered distance of 501-600m and 601-700m compared to 18(4.8%) and 5(1.3%) among private school students, respectively.

There was a weak positive correlation of the test with age and height ($p<0.001$), but not with weight, gender and BMI ($p>0.05$). Gender was identified as an independent factor with regard to 6MWT (Figure).

Of the 225 boys, 66(42.3%) took a break, while 159(17.6%) completed 6MWT without taking any rest. Among the 151 girls, 44(11.7%) took a break and 107(28.5%) finished the test without any break ($p>0.05$). Among 167 public school students, 3(1.8%) students took a break compared to 107(51.2%) of the 209 private school students ($p=.0001$).

Significant difference was observed in mean HR, RR, SPO_2 and RPE values before and

Table-1: Anthropometric characteristics (n=376).

Variable	All participants Mean ± SD	Gender Mean±SD		*p*-value	School type Mean±SD		*p*-value
Age	9.25 ± 1.64	Boys (n=225)	9.67± 1.59	0.000***	Public (n=167)	9.44± 1.41	0.045***
		Girls (n=151)	8.64± 1.53		Private (n=209)	9.11± 1.79	
Height (cm)	134.03± 10.93	Boys (n=225)	135.26±11.20	0.008***	Public (n=167)	135.3±10.72	0.035***
		Girls (n=151)	132.21±10.29		Private (n=209)	132.9±11.01	
Weight (kg)	28.66± 7.41	Boys (n=225)	29.68± 7.55	0.001***	Public (n=167)	28.92± 6.83	0.554
		Girls (n=151)	27.14± 6.95		Private (n=209)	28.46± 7.86	
BMI	15.92± 3.49	Boys (n=225)	16.21± 3.78	0.045***	Public (n=167)	15.61± 2.92	0.125
		Girls (n=151)	15.48± 2.95		Private (n=209)	16.16± 3.87	
6MWT	482.63±119.76	Boys (n=225)	483.10±126.77	0.926	Public (n=167)	586.4±79.42	0.001***
		Girls (n=151)	481.92±108.88		Private (n=209)	399.7±72.56	

SD: Standard deviation, BMI: Body mass index, 6MWT: Six-minute walk test.

Table-2: Six-minute walk distance according to age.

Age (years)	Mean±SD	Minimum	Maximum
7	409.04±94.41	304.80	655.32
8	494.49±115.21	304.80	822.96
9	506.85±108.32	304.80	762.00
10	507.21±122.09	304.80	838.20
11	519.53±115.95	304.80	792.48
12	469.66±130.39	304.80	792.48
Total	482.63±119.76	304.80	838.20

Table-3: Comparison of cardiovascular parameters and perceived rate of exertion following six-minute walk test (6MWT).

Variables	Pre-Walk Mean ± SD	Post-Walk Mean ± SD	Mean Difference	*p*-value
Heart Rate	84.25 ± 5.39	93.95 ± 6.47	-9.699±3.199	0.000***
Respiratory Rate	24.10 ± 3.50	31.28 ± 3.74	-7.181±1.844	0.000***
SPO_2 (%)	96.78 ± 3.33	95.59 ± 5.79	1.191±4.72	0.000***
RPE	0.0±0.0	4.42±0.49	-4.418±.499	0.000***

SD: Standard deviation, SPO_2: Saturation of peripheral oxygen, RPE: rate of perceived exertion.

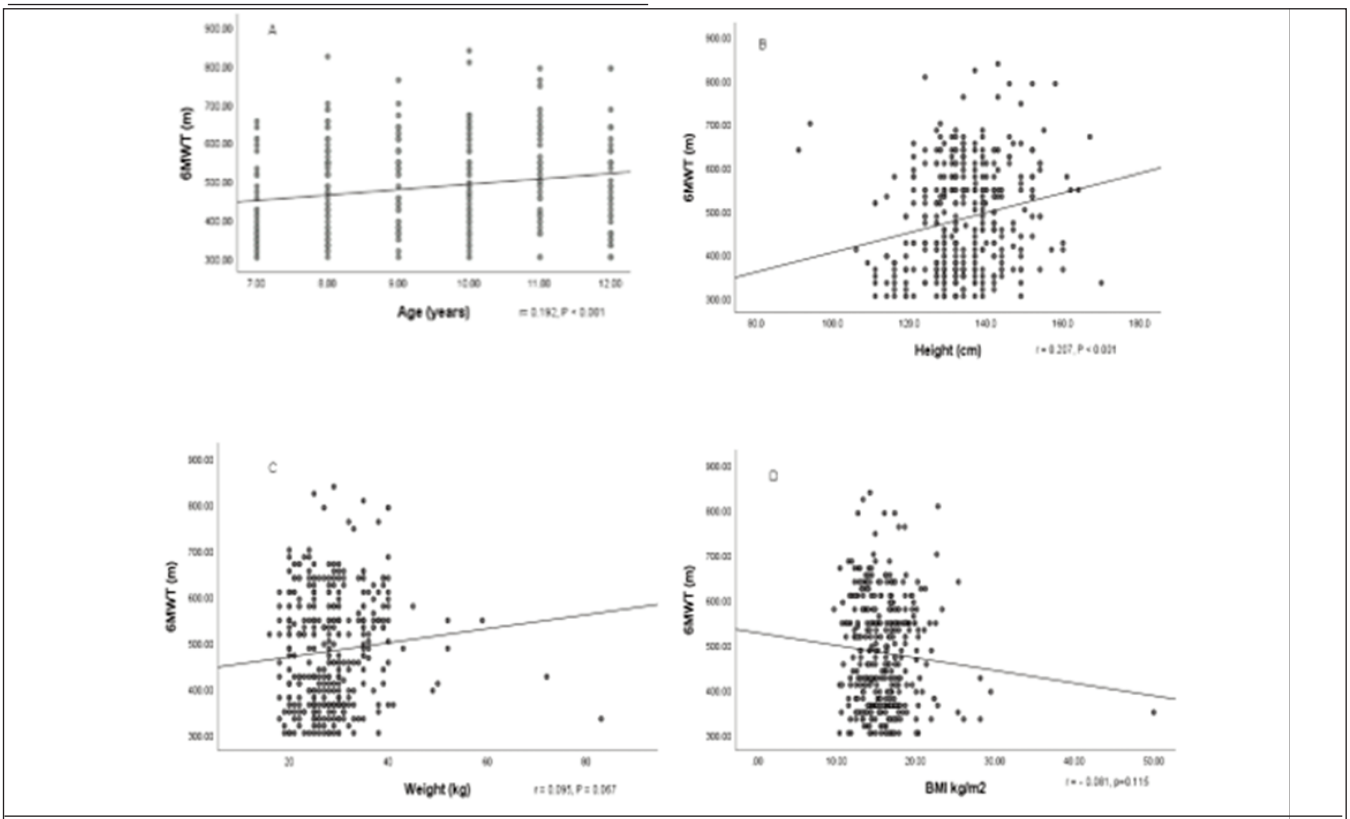

Figure: Scatter plot showing correlations between six-minute walk test (6MWT) with age (A), height (B), weight (C) and body mass index (BMI) (D).

after 6MWT for all students (Table 3).

No significant differences were observed for cardiovascular parameters of boys and girls ($p>0.05$), while the difference was significant between RPE and gender (Table 4).

Discussion

The current study determined the functional ability of children aged 7-12 years and found that it increased with age. A prospective study also reported similar findings.[4] As in previous cross-sectional surveys, boys covered higher average distance than girls.[11,25] One study highlighted significant correlation of 6MWT with age, height and step length.[16] One study concluded that 6MWT depended on age, and that anthropometrics were more vital in adolescents and females.[26] Girls aged 6-11 years improved 6MWT score and reached the maximum value at 10 years, with 6MWT having positive correlation with age and height.[2] Another study found positive correlation of 6MWT with male gender, age, weight and BMI, and negative correlation with waist and hip circumference for both genders.[21] Significant relation of 6MWT with age and gender were reported by another study, which found no significant relation between BMI and 6MWT.[18]

In the current study, HR, RR SPO_2 and RPE values had significant difference pre- and post-6MWT. One study also found increase in mean SPO_2 and HR values post-6MWT in healthy children aged 4-11 years.[4] Another study reported increase in HR, but there was no significant change in SPO_2 and dyspnoea.[25]

The current study has its limitations. The sample size was small, gender and public-private distribution was not equal, and varying temperatures and shoes worn by the students could have had an impact on the distance covered. In private schools, 100-foot distance, that is the main requirement of 6MWT, was not available, and the distance had to be divided into 50 feet. Due to limited time, 6MWT was conducted once which might have had a training effect on test performance.

Conclusion

The functional ability of healthy school-going children aged 7-12 years increased with age. Distance covered by boys and public-school students was greater than female and private students of same age. Anthropometric measurements and physiological parameters significantly affected 6MWT performance.

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Conflict of Interest: None.

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