International Journal of Contemporary Pediatrics
Singh V et al. Int J Contemp Pediatr. 2017 May;4(3):921-926
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20171699

Original Research Article

Six minutes walk test outcome measures in children

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Received: 03 February 2017
Revised: 05 March 2017
Accepted: 10 March 2017

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ABSTRACT

Background: There are limited numbers of studies on 6 MWT in school going children in India. Objectives were to know gender wise outcome measurements for 6 MWT and its correlation with various anthropometric parameters, to make comparison of results between children of various socio-economic groups.
Methods: After a randomized selection of schools a total of 500 children belonging to different socioeconomic status and studying in Government and Private Schools aged between 7-12 years were enrolled in the study. At the start, anthropometric measurements and baseline parameters like HR, BP, SPO2, PEFR, level of dyspnea were recorded and then children were made to walk for 6 minutes. After the walk changes in these parameters were taken as outcome measures.
Results: The Mean distance walked in 6 minute was 609 ± 166 m. Boys covered more distance than girls. Heart rate increased from a baseline of 82.73 ± 1.63 to a maximum of 104.32 ± 3.11; heart rate recovery occurred (>90%) at 5 min in both the genders. SBP (systolic blood pressure) increased from baseline 109 ± 2.38 to maximum of 121.86 ± 1.75 at the end of the test, with no significant increase in DBP. The 6 minute walk distance correlated well with higher level of dyspnea. No significant change in oxygen saturation was observed during the test.
Conclusions: The study provides data on normal values of 6MWT in healthy children, which may help to evaluate functional capacity and thus predict the morbidity risk in future and to know the effects of therapeutic interventions in the diseased children.

Keywords: Exercise tolerance, 6 MWT, Submaximal exercise

INTRODUCTION

In the present-day scenario where health issues have become a major concern, being healthy not merely means having appropriate weight as per age but there are multiple parameters related to respiratory and cardiac responses which defines physical fitness. As we know many diseases of adult life take their origin from childhood. Therefore, if we are able to address them early they would be more predictable and manageable. Exercise tolerance test have been practiced in schools as a tool to measure fitness and cardiovascular response to exercise but most of these activities are skill related rather than cardiovascular fitness test.

Most of the daily activities are performed at submaximal levels of exertion. Therefore, submaximal functional tests are better reflection of physical capability.[1] Among the modalities available for the objective evaluation of functional exercise capacity 'six-minute walk test' (6MWT) is easy and quick to administer, economical, better tolerated, reproducible and more reflective of activities of daily living. Moreover, its self-paced nature makes it a very safe evaluation.

6MWT is being increasingly used in young children, in whom performing typical cardiopulmonary exercise tests is a bit cumbersome, requiring a high degree of coordination and motivation but lack of 6 MWD reference values for normal, healthy children causes hindrance on clinical usefulness of this test in pediatric age group. Normal values for 6MWT has been reported in Chinese, Caucasian, and UK children.[2-5] The individual response to exercise is an important clinical assessment tool because it provides a composite assessment of respiratory, cardiac and metabolic system.[6-8]

Only few studies on 6MWT have been done among Indian Children till date[11].The present study was therefore designed to establish a normal reference values in children aged 7-12 years along with impact of socio-economic status and correlation with anthropometric measurements in school going children, aged 7-12 years in urban area of one of the district in Madhya Pradesh.

METHODS

After the approval from ethical committee, 500 healthy children were recruited randomly from various government and private schools of Gwalior, in order to incorporate children from various socioeconomic strata.

Before recruitment, purpose and method of study was explained to each participating school and then permission was taken to carry out the study from school authorities. A questionnaire was completed and an informed consent was obtained from their parents. Inclusion and exclusion criteria were fulfilled before enrollment of subjects.

Exclusion criteria

Any cardio respiratory problems, including:

- Asthma, bronchiectasis
- Congenital heart deficit and hypertension
- Exercise problems (e.g., neuromuscular or musculoskeletal diseases)
- Hospital admissions within the past 3 months
- Common-cold within last 4 weeks, or long-term medication that could interfere with walk test.

Inclusion criteria

- Healthy children between 7 to 12 years of age.

Selected children were explained in brief regarding the study. Subjects included were pre-evaluated. Subjects' weight and standing height were measured with a calibrated weighing scale in kilograms and inch tape measurement in centimeters.

The test was conducted according to a standardized protocol using an internal hallway with the 100-foot distance marked by colored tape on the floor. The subjects were told, the purpose of the test is to see how far they can walk in 6 min. They were instructed to walk up and down the hallway covering as much ground as they can during 6 min.

The test was self-paced and the subject could rest if he or she so wish. The subjects were made to rest in a chair, located near the starting position, for 10 min before commencement. During this period, resting pulse, oxygen saturation (using finger tip pulse oximeter) and blood pressure (Sphygmomanometer) and PEFR (peak expiratory flow rate) were measured. The 6MWT was performed by a single investigator who counted the number of laps completed, and used electronic time. The distance covered over the 6 min was recorded in meters (6MWD). Pulse, blood pressure, dyspnea (modified borg scale), peak expiratory flow rate and oxygen saturation were recorded immediately at the end of the test and during the recovery period of 3 and 5 min.[11]

RESULTS

The present study consisted of 500 children of Gwalior aged between 7-12 years. Data were analyzed with statistical package social science version 16. p value of <0.001 with confidence interval of 95% was considered statistically significant. Comparisons between age groups were made using Kruskal Wallis test/student t-test. The number of individuals in each age group, gender, distribution, weight, height, BMI, HR, BP, PEFR, SPO_2 at rest, immediate, 3 min and 5 min and distance walked in 6 min.

The mean distance walked increased from 529.39±61.9m in children of 7 y to 675.6±110.9m at 12 years, on analysis using two-way ANOVA, there is significant difference between the age groups (p<0.001). The mean 6-minute walk distance decreased by 37m between 7-8years, increased by 103m between 8-9 years, increased by 14m between 10-11years, and increased by 55m between 11-12 years. The mean distance covered correlated with the socioeconomic status (Graph-2) with a mean distance of 668.73±147.6 in upper class while in lower class mean distance 577.13±69.68 with statistically significant difference (p <0.001).

The difference between the distance covered of boys and girls was statistically significant. The mean distance covered by girls was 570.68±96.6 whereas in boys it was 602.09±91.8. On gender comparison amongst the government and private school children (Figure 1). The difference in the distance covered was significant between the girls and boys in government group (p <0.001). There was no such statistically significant difference in private school children.

Table 1: Results of 6 min walk test in different age groups in boys.

Age (years)	7	8	9	10	11	12
Total no.	**41**	**39**	**42**	**42**	**42**	**41**
Height(cm)	119.19(4.2)	128.03(5.1)	128.82(7.9)	147.6(4.8)	141.09(7.2)	143.65(6.9)
Weight(kg)	19.8(4.3)	25.15(5.3)	26.61(6.2)	41.69(5.4)	37.15(13.2)	39.10(9.4)
BMI	13.97(2.4)	15.01(6.2)	16.03(5.1)	19.13(3.9)	18.51(4.8)	18.11(4.1)
SPO_2						
Baseline	97.12(2.1)	97.56(1.6)	98.42(2.2)	99.09(1.9)	98.36(1.4)	98.24(2.1)
Immediately	97.75(1.4)	97.99(1.8)	97.81(1.6)	98.18(2.1)	98.17(2.4)	97.44(2.3)
3min	97.6(2.1)	98.12(2.2)	96.39(2.3)	98.16(1.8)	97.98(1.5)	94.66(1.4)
5min	97.77(1.8)	98.45(1.6)	97.79(1.6)	98.09(2.1)	97.96(1.5)	97.18(1.8)
HR						
Baseline	96.80(9.2)	94.51(9.8)	97.12(8.7)	97.53(5.4)	96(11.3)	93.48(12.5)
Immediately	110.94(11.8)	115.7(8.2)	119.12(13.2	127.76(16.1)	118.46(7.6)	138.94(8.9)
3 min	102.44(8.7)	108.94(5.4)	108.2(11.6)	112.96(11.1)	115.59(10.8)	117.26(6.9)
5 min	97.35(7.6)	100.97(6.3)	102.23(9.9)	107.08(12.4)	106.01(9.5)	110.31(11.7)
SBP						
Baseline	107.3(7.8)	104.92(8.2)	99.04(6.9)	100.28(6.9)	102.98(7.6)	102.78(6.9)
Immediately	110.57(9.2)	110.52(8.7)	109.23(7.9)	113.99(8.4)	112.15(7.9)	116.92(6.9)
3min	107.72(8.9)	108.99(5.9)	105.57(6.9)	109.48(11.2)	108.93(8.4)	108.44(5.9)
5min	105.5(7.8)	103.45(5.8)	104.53(7.2)	105.06(7.9)	103.99(5.9)	105.13(8.7)
DBP						
Baseline	67.02(5.2)	64.87(6.1)	66.71(4.2)	69.49(4.7)	65.76(6.1)	63.90(5.6)
Immediately	69.65(4.8)	67.23(4.4)	67.33(3.6)	69.95(5.2)	67.91(5.5)	66.45(6.2)
3 min	68.61(5.2)	65.85(3.2)	66.1(6.1)	69.07(4.9)	67.48(6.2)	65.77(5.6)
5 min	66.29(6.2)	64.02(4.2)	65.96(5.4)	68.37(5.2)	67.34(5.9)	65.68(6.1)
PEFR						
Baseline	155(13.9)	159(25.2)	178(47.9)	184(44.7)	189.2(26.1)	192.9(42.2)
Immediately	171(17.5)	172(25.8)	191.43(54.3)	198.8(51.9)	213.2(22.76)	271(94.8)
3 min	141(32.9)	138.9(28))	177.9(49.4)	145.38(28)	216.7(64))	208.54(37.3))
5 min	152(26.9)	152.8(36.2)	175(67.4)	173,8(63)	222.9(41.6)	213(47)
6 MWD	487.95	474.44	600.09	618.63	607.32	632.93

Values are presented as mean±SD, BMI, Body Mass Index; HR, Heart Rate; SBP, Systolic Blood Pressure; SPO2, Transcutaneous O2 saturation, DBP- Diastolic Blood pressure 6MWD-6 Minute Walk distance

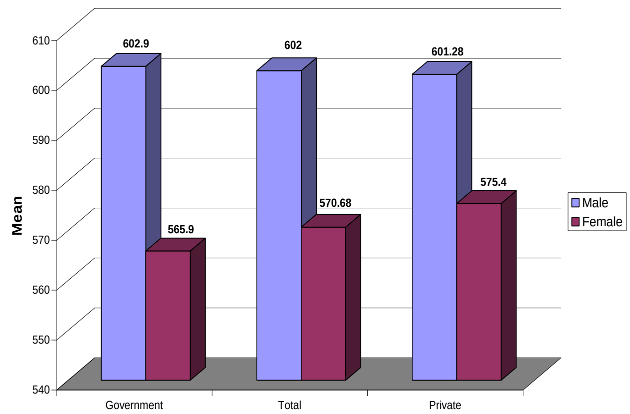
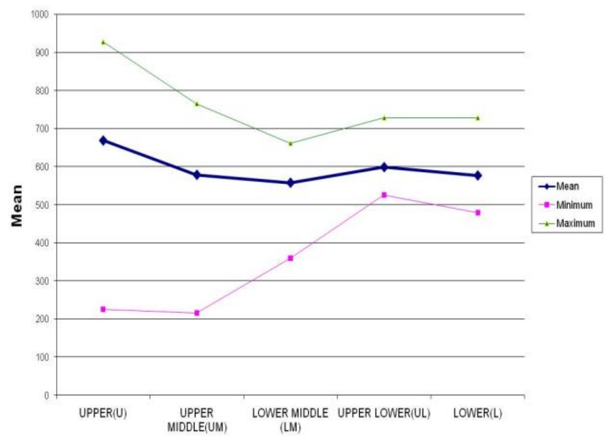


Figure 1: Mean 6 minute walk distance according to gender and school type.

The distance walked correlated with weight (r=0.4; p<0.001), height (r=0.5; p<0.001), dyspnea scores (r=0.2, p<0.001) on univariate regression analysis. Regression analysis shows that dyspnea, age, weight, height are significant predictors of distance covered.



χ_2 - 49.7, df = 5, p value = 0.001

Figure 2: Mean 6-minute walk distance according to socioeconomic class.

The HR increased from baseline of 96.1±8 bpm, reaching a plateau of 121.82 bpm immediately after the test, at 3 min 110.94±11 and at 5 min 104.1±12.4 bpm in girls where as in boys the baseline heart rate was 88.51±9.7 bpm rising immediately to 110.27±8.2 at 5 min and at 3 min 99.74±5.1 and returning to 94.26±9.8 at 5 min. Heart rate following exercise was more in girls compared to boys and also higher in private school compared to government school children. There was no difference, in the recovery of HR attained at 5 minute, in between boys and girls and also between the government and private school groups.

There was a significant rise in SBP from baseline 103.5±7.3 to immediate 114.1±8.2.in males and from baseline of 102.8±9.1. to immediate of 108.18±7.2 in females. In males SBP dropped little from baseline and came at 101.8±7.7 whereas in females it was 104.9±5.3. The rise from baseline to immediate was more in boys compared to girls. There was also significant difference, in the recovery of systolic blood pressure at 5 minute, in between the boys and girls of the two groups.

Table 2: Results of 6 min walk test in different age groups in.

Age (years)	7	8	9	10	11	12
Total no.	44	42	42	42	42	41
Height(cm)	117.01(6.1)	120.01(9.6)	127.91(12)	133.17(13.1)	140.89(6.8)	145(13.4)
Weight(kg)	17.43(4.6)	19.56(6.7)	31.17(7.9)	30.71(8.9)	29.15(13.2)	29.05(11.1)
BMI	12.53(4.1)	13.34(7.2)	17.87(6.9)	17.05(9.8)	14.51(6.9)	13.59(12.6)
SPO_2						
Baseline	97.86(2.1)	96.64(1.5)	96.74(2.5)	95.87(3.2)	97.92(3.2)	97.66(2.1)
Immediately	96.59(2.1)	97.30(2.1)	97.59(2.3)	97.38(3.2)	97.07(1.9)	97.87(3.1)
3min	96.43(1.5)	97(2.9)	97.26(2.4)	97.28(3.1)	96.45(2.9)	97.36(2.4)
5min	96.67(2.3)	96.35(2.8)	97.26(1.9)	97.42(1.9)	97.5(2.9)	97.95(2.5)
HR						
Baseline	82.85(4.8)	84.73(11.2)	91.97(13.2)	90.19(13.1)	90.4(9.8)	89.88(10.1)
Immediately	101.18(5.2)	104.03(8.9)	113.51(11.8)	110.17(11.4)	111.62(9.7)	121.12(11.1)
3min	96.52(4.9)	96.46(7.9)	100.49(8.9)	98.89(12.1)	99.39(8.9)	106.81(9.5)
5min	91.42(3.6)	84.56(9.6)	99.03(10.1)	95.94(9.9)	95.24(11.2)	89.62(10.1)
SBP						
Baseline	106.38(7.2)	102.57(6.8)	104.76(5.9)	104.42(6.4)	102.5(6.7)	100.54(9.8)
Immediately	115.47(6.8)	111.71(7.4)	114.90(6.7)	113.94(7.2)	115.7(7.4)	112.88(7.9)
3min	111.19(7.2)	106.48(8.5)	108.33(7.1)	107.94(5.9)	111.05(6.1)	106.69(6.9)
5min	104.39(4.8)	99.28(7.5)	101.48(8.5)	101.56(8.7)	104.1(7.1)	100.26(6.9)
DBP						
Baseline	67.71(3.2)	63.95(5.2)	67.14(4.9)	66.52(5.6)	63.15(6.1)	62.82(5.7)
Immediately	71.17(3.4)	69.14(4.9)	69.71(3.9)	69.28(6.2)	67.9(4.8)	68.38(6.2)
3min	68.71(4.1)	67.14(5.2)	68.71(4.6)	68.24(5.4)	66.35(5.9)	67.17(5.1)
5 min	67.81(3.4)	67.42(4.9)	67.39(6.3)	67.2(4.8)	64.15(6.1)	66.29(7.1)
PEFR						
baseline	144(18.3)	143(20)	159.8(21.8)	192(55.8)	188(28.7)	177(31)
immediate	146(27)	160(20.7)	155.7(18.3)	222(51.7)	213(22.7)	199.7(64.3)
3min	167(47)	194(70.8)	173.4(27)	171(61.4)	176.6(54.7)	190.7(58.9)
5min	139(27.6)	143(22.1)	133.9(12.9)	194(74.9)	174(34.3)	178.2(62.7)
6 MWD	568.48	507.68	590.32	594.22	637.35	720.3

Values are presented as mean±SD, BMI, Body Mass Index; HR, Heart Rate; SBP, Systolic Blood Pressure; SPO2, Transcutaneous O_2 saturation; DBP- Diastolic Blood pressure 6MWD-6 Minute Walk distance.

Diastolic BP at baseline was 65.24±4.5 with mild increment immediately after test, and was 66.7±5.5 at 5 min in males. Whereas 66.2±6.9 at baseline and 66.9±6.6 at 5 min in females. There was no significant variation in DBP among the groups. Higher scores of dyspnea (2-6) were correlating significantly with the distance covered (r=0.2, p<0.001).

Values of PEFR were higher in boys as compared to girls, and this relation was true in government children but not in private children where the boys and girls have difference in PEFR which is not significant. Relationship of 6MWD with BMI was not consistent. No significant variation in oxygen saturation was observed following the test in healthy children. Mean oxygen saturation of 98 at baseline dropping to 97% at the end of test and saturation coming back to 98 at within 3 min. There was no significant effect of age ($p \leq 0.001$) and gender ($p= <0.001$) on saturation.

DISCUSSION

The current study reports data on normal values of 6MWD in children aged 7-12 year in India. In healthy individuals, the 6 MWT represents a sub maximal exercise test, thus reflecting patients ability to perform day to day activities. Previously studies have been conducted reporting normal values for 6 MWD in almost similar age groups amongst Chinese, Caucasian and U.K. children.[3-5] The current study establishes normal values for 6 MWD and the effect of anthropometric measurements, BP, HR, PEFR, SPO_2 and dyspnea separately for boys and girls and also the effect of socioeconomic status on distance walked.

The mean distance of the entire group in the present study was (586.45±95.45m) which is comparatively less than that of Chinese children (660±58m) (aged 7 to 16y), Caucasian (694±43m) and more than the UK (470±59) (aged 4 to 11y) population. In present study Boys covered more distance than girls similar to the study conducted by D silva (609± 166).[10] The greater distance may be related to increase in height (9) and the nutrition status. The male subjects in the present study had significantly greater height and good nutrition status and this could explain the gender difference seen in the distance covered in 6 minute. Among all the anthropometric measurements, height had the best correlation with 6 MWD. Taller people could have larger stride length and thus walk greater distance[3].But insignificant difference amongst girls and boys of private school could be attributed to good nutrition status in both the groups due to better rearing, owing to higher education and socioeconomic status of parents. In this study, there was significant drop in distance walked between the age of 7 to 8 year, this can be attributed to more number of athletes and high level of motivation in the age group of 7 year, whereas, in the age group of 8y the children were more involved in indoor games.

Heart rate is a practical and relatively easy way to assess physiological strain and differences in cardiorespiratory function between the individuals.[12] Heart rate increased significantly from baseline to the end of the test. Baseline Heart rate and heart rate during exercise was higher in girls compared to boys which was similar to study done on UK children whereas contradicting to the study done on Chinese children. Heart rate recovery is the decrease in the heart rate from peak exercise to 1 min. after cessation of exercise.[13,14] Delayed 1-min. HR recovery on cessation of exercise is a predictor of cardiovascular risk factor. Delay in HR recovery implies impaired activity of the parasympathetic component of the autonomic nervous system and thus a relative sympathetic dominance.[15,16]

In the present study, HR recovered at 5 min. in both genders, which is contradicting to the previous studies where heart rate recovery was reported at 1 min. after the peak exercise, similar results were found by Silva D et al where heart rate increased from a baseline of 82.73±1.63 to a maximum of 104.32±3.11; heart rate recovery occurred at 5 min in both the genders.[10]

Late recovery may be either due to lower exercise endurance or higher BMI. In the present study, the reason could be lower level of endurance.

Systolic blood pressure raised significantly from the baseline for both genders due to higher contractile force of the myocardium during exercise. But males had a higher systolic BP than females because of higher stroke volume. SBP came back to normal at 5 min in females where as it declined little in males from the baseline, which can be attributed due to increased venous pooling following exercise testing.[18,19] Diastolic blood pressure almost retained constant from baseline to immediate values without any variation in both male and females. Vasodilatation during exercise generally causes diastolic pressure to remain unchanged.[19] No significant change in oxygen saturation was seen which was similar in all studies done previously.[3-5,10] PEFR values increase immediately following exercise from the baseline in normal subjects. PEFR values were higher in boys compared to girls and also there was significant difference between them in the recovery of mean PEFR. Higher values in boys could be due to better pulmonary efficiency owing to increase level of physical activity. No difference between the boys and girls of private school can be attributed to similarity in their activity level and moreover to the comprehensive development.

With normative values gained from this study, values measured from the children with impairment can be compared. This will enable health care professional or the physical education teacher to monitor a child's progress especially if they are receiving therapy for a diseased condition.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Singh V, Verma YS. Six minutes walk test outcome measures in children. Int J Contemp Pediatr 2017;4:921-6.