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Reference Values and Relationship of the Six Minute Walk Test and Body Mass Index in Healthy Third Grade School Children

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Abstract
Purpose: This study attempted to establish reference values of the six-minute walk test (6MWT) for children (38 males; 38 females; age 90-108 months) and to determine the relationship between Body Mass Index (BMI) and walking distance. Method: Subjects walked at a normal, self-selected, walking speed on a grassy field for six minutes, after which distance was measured. Results: Mean BMI was 15.5 (sd=2.00) for males and 16.3 (sd=2.9) for females. Mean walking distance was 581.7 m (sd=58.10) for males and 532.2 m (sd=52.6) for females. The partial correlation between BMI and distanced walked with the influence of gender removed was .10 ($p > .05$). The partial correlation between BMI and distanced walked with the influence of age removed was .02 ($p > .05$). There was no relationship between distance walked and BMI. Conclusions: Reference values of the six-minute walk test for healthy, third-grade school children were calculated and reported.

Background
Obesity is a problem of increasing prevalence in children that may lead to many health problems in adulthood.[1,2] In adults, a lack of physical activity may lead to decreased aerobic capacity and function that in turn increase the risk of developing many health conditions, which may include diabetes, cardiovascular disease, hypertension, pulmonary disease, stroke, osteoarthritis, and cancer.[3] Early preventative action may be necessary to curve the increasing epidemic of obesity in children.[4,5]

An underlying source of the problem may be a lack of physical activity in children, which may be continued into adulthood.[6] Kraut, Melamed, Gofer, and Froom predicted that participating in organized school-age sporting activities increased the amount of leisure time physical activity as an adult.[7] Salbe, Fontvieille, Harper, and Ravussin reported that the total energy expenditure in five-year-old children in the United States was 25% lower than recommended by the World Health Organization, because of decreased physical activity.[8] It has been further suggested this decreased activity is related to the increased prevalence of obesity.[8]

Exercise testing has been previously conducted in physical education classes as a means of determining physical fitness. However, these tests have focused on skill-related activities rather than health-related fitness, such as cardiovascular and pulmonary fitness[2]. The six-minute walk test (6MWT) has been used as an assessment tool in cardiac and pulmonary rehabilitation programs for adults.[3,9-13] The 6MWT is a sub-maximal test of aerobic capacity in which subjects walk as far as they can in six minutes around a pre-measured distance. It is used most often to assess function in patients with cardiovascular and pulmonary disease.[10-13]

Walking tests, such as the 6MWT, have not been used very often in the healthy, pediatric population as assessment tools. The 6MWT may be a useful assessment tool for children because walking is a part of everyday life. The test is safe, cost effective, and easy to administer. It may also be more likely to hold the child's attention because it is brief and easy. The 6MWT is a sub-maximal test, which puts less stress on the cardiovascular system than a maximal test. Using a sub-maximal test allows children with impairments to participate, whereas a maximal test might be too taxing. It is important to identify normative values for healthy subjects before examining children with impairments.

Body Mass Index (BMI) is a screening tool used to

assess a person's weight relative to their height and is determined by dividing body weight in kg by height in meters squared (kg/m^2).[14] For adults, overweight has been defined as having a BMI of 25-29 kg/m^2; whereas, obese has been defined as having a BMI greater than or equal to 30 kg/m^2. For children, overweight is defined as a percentile rank of 95% or greater for a child's age.[14] At risk of overweight for children is defined as between a percentile rank of 85% and 95% for the child's age. In 1997, the International Obesity Task Force found that BMI was a valid measure of adiposity in children.[15] The percentage of children in the United States who are overweight or obese is increasing at an alarming rate. Vincent et al. found that the percentage of children who are overweight has more than doubled in the past thirty years.[16]

Vincent et al. used pedometers to compare activity levels and BMI in children in several countries.[16] They concluded that the percentage of children who are overweight or obese increase as activity levels decrease. An assessment of activity levels of children at an early age is important. The 6MWT and body mass index (BMI) may both assist in assessing a child's activity level.

Children as young as first grade showed a decline in the amount of physical activity that they perform.[17] The National Center for Health Statistics indicates that approximately one-in-five children in the United States is overweight. [18] The likelihood of obesity in children should be examined in relationship to their physical activity and function. It is important to incorporate a measure of obesity into the assessment of cardiovascular and pulmonary fitness to obtain an overall picture of the child's health. Previous studies have been conducted on either the treadmill or cycle ergometer. These can be costly and it is difficult to maintain the child's attention.[18] Few studies have used walk tests to assess aerobic performance and function in children.

This study examined the performance of third graders during the 6MWT to determine baseline reference values for healthy children. It is important to also examine the likelihood that a child with obesity would perform poorly on the 6MWT as a test of cardiovascular and pulmonary fitness. The purposes of this study were: (a) to establish reference values of the 6MWT for third-grade school children between the ages of 90 months to 108 months (7.5 to 9 years), and (b) to assess the relationship between BMI and performance on the 6MWT.

Methods

Sample

This study was approved as safe for human subjects by the Institutional Review Board (IRB) of the Arizona School of Health Sciences (ASHS), a division of A.T. Still University. All subjects participating in this study were required to have their parent/guardian sign an informed consent before their participation. In addition, the parent/guardian completed and signed a medical screening form for their child. The sample of this study consisted of healthy, third-grade students from two elementary schools in the Phoenix metropolitan area. The sample size consisted of 38 males and 38 females. The ages of the children were between 90 months and 108 months (7.5 and 9 years). Only students in the third grade were allowed to participate in this study. Subjects were excluded from this study if they had diabetes mellitus, cancer, any fractures within the past six months or known musculoskeletal, congenital, cardiac or pulmonary conditions (except controlled asthma). Seven children (3 males, 4 females) reported they had asthma that was controlled by medication if needed. These children participated in the study without incident. Each subject was tested for the 6MWT two times during the course of the study.

Data Collection and Procedures

A standard calibrated bathroom scale was used on the first testing day to measure the subject's body weight. The subjects were instructed to remove their shoes prior to taking their measurements. Each subject was instructed to stand on the scale while the investigator recorded their weight rounded to the nearest kilogram. The same investigator measured each subject's weight. The subjects were then instructed to stand with their back against the wall next to a standard yard stick. The investigator measured the subject's height to the nearest inch. The same investigator measured each subject's height. Values were later converted to metric units for BMI calculation.

The facilities used for testing were the playing fields of each of the two schools. The testing areas were inspected to insure the surfaces were safe for the activity. Data collection was performed in the early afternoon during the months of October and November. The temperatures during the times of data collection ranged between 75 and 85 degrees Fahrenheit. A 200-foot course was measured on the school's playing field at the beginning of each testing day with the use of a standard 25-foot tape measure. The square-shaped course had a cone in each corner as well as four cones marking every 25-feet from the corners, for a total of eight cones.

The investigator organized each group of subjects on the starting line with no more than 16 subjects per group. A standard stopwatch (Athletic Works, Walmart, Bentonville, Arkansas) was used to time the 6 minutes of each test. For data collection, one investigator instructed the students to "Start" and started the stopwatch. The subjects were instructed to "Walk, don't run, skip or hop, and stay around the outside of the cones." Plastic straws were given to each subject after the completion of each lap. During the six minutes the investigators gave words of encouragement such as "Good job" and "Keep up the good work." The subjects were instructed to hold their straws until an investigator was able to collect the straws and measure the distance walked. After six minutes, the

investigator stated, "Freeze" to the children, which indicated the completion of the test. The straws were collected and the distance walked was measured. The same investigator measured the time on all of the trials to maintain consistency. Testing was conducted on two occasions during a five-day period, but not on the same day. The average distance for the two occasions was used for data analysis.

Data Analysis Procedures

The variables that were analyzed included height, weight, age (in months), distanced walked, and body mass index (BMI). Data analysis was performed using descriptive statistics including means, standard deviations, skewness, kurtosis, and percentiles. A t-test was performed to determine if there were significant differences in distance walked according to gender. In addition, partial correlations were calculated to determine the relationship between BMI and distanced walked with the influence of gender removed as well as the relationship between BMI and distanced walked with the influence of age removed. Microsoft Excel (Redmond, WA) and Statview 5.0 (Cary, NC) statistical packages were used for data analysis.

Results

Thirty-eight males and thirty-eight females between the ages of seven-and-a-half and nine years participated in this study. The descriptive statistics for the data can be found in Table 1.

TABLE 1. Descriptive statistics for the sample.

	Females				Males		
	Age(months)	Height(meters)	Weight(kg)		Age(months)	Height (meters)	Weight (kg)
Mean	102.90	1.32	28.76		102.90	1.34	28.11
SD	3.50	0.06	7.32		3.50	0.06	5.09
N	38	38	38		38	38	38
Skewness	0.69	0.27	1.31		0.69	-0.28	1.03
Kurtosis	0.30	0.85	2.00		0.30	0.00	0.73

A hypothesis that there were differences in distance walked by gender was performed using a t test for independent data. At an alpha level of .05 there was a mean difference according to sex of 49.45 m ($t = 3.892$; $df = 74$; $p = .002$). Therefore, any development of reference values for the 6MWT for the sample must be sex specific.

Distances walked in the 6MWT were a key statistic for this study, as it was hoped the variability of the data would closely fit that of the normal distribution. The mean 6MWT distance for the boys and girls were 581.70 and 532.20 ft respectively. The skewness for a normal distribution is generally considered to be zero.[19] The kurtosis for a normal distribution is generally considered to be three; however, the computer program used in the study normalizes the kurtosis to zero.[19] If the variability fit the normal distribution, percentiles could then be calculated. [19] A 95% confidence interval was used to test the null hypothesis that the data fit a normal distribution. If zero is included in the range of the confidence interval, the null hypothesis can not be rejected. [19] The data was slightly skewed negatively, but zero was included in the range of the confidence interval (Table 2).

Therefore, it can be concluded that the data in this study did not depart significantly from a normal distribution. The kurtosis for the data was slightly platokurtotic, but zero was included in the range of the confidence interval. Again, the data did not differ from a normal distribution. The percentiles for the sample were therefore calculated separately for males and females and can be found in Table 3.

The second purpose of the study was to assess the relationship between BMI and performance on the 6MWT. The relationship between distanced walked and BMI was -.20 for females ($t = 1.24$; $CV = 2.02$; $p > .05$) and .10 males ($t = 0.63$; $CV = 2.02$; $p > .05$). Neither relationship was significant at an alpha level of .05. The calculated partial correlation between BMI and distanced walked with the influence of gender removed was .10, which was not significant at an alpha level of .05 ($t = 0.83$; $CV = 2.00$; $p > .05$). The calculated partial correlation between BMI and distanced walked with the influence of age removed was .02, which again was not significant at an alpha level of .05 ($t = 0.17$; $CV = 2.00$; $p > .05$). It can be concluded that there is no relationship between distance walked and BMI.

TABLE 2. Means, Standard Deviations, Skewness, Kurtosis, and 95% Confidence Intervals for distanced walked.

	Females		Males	
	Body Mass Index (kg/M^2)	Distance (meters)	Body Mass Index (kg/M^2)	Distance (meters)
Mean	16.3	532.2	15.5	581.7
SD	2.9	52.6	2.0	58.1
N	38	38	38	38
Skewness	0.95	-0.26	0.96	-0.76
95% CI Lower Limit	0.15	-1.06	0.16	-1.56
95% CI Upper Limit	1.75	0.54	1.76	0.04
Kurtosis	0.69	-0.26	1.00	0.5
95% CI Lower Limit	-0.92	-1.87	-0.61	-1.11
95% CI Upper Limit	2.30	1.35	2.61	2.11

TABLE 3. Percentiles for distanced walked by gender.

	Females			Males	
Percentile	Distance Walked (m)	Distance Walked (ft)	Percentile	Distance Walked (m)	Distance Walked (ft)
P95	619	2030	P95	677	2222
P90	600	1967	P90	656	2152
P85	587	1925	P85	642	2106
P80	576	1891	P80	631	2069
P75	568	1863	P75	621	2037
P70	560	1837	P70	612	2009
P65	552	1813	P65	604	1982
P60	546	1790	P60	597	1957
P55	539	1768	P55	589	1932
P50	532	1746	P50	582	1908
P45	526	1724	P45	574	1885
P40	519	1702	P40	567	1860
P35	512	1680	P35	559	1835
P30	505	1655	P30	551	1808
P25	497	1630	P25	542	1780
P20	488	1601	P20	533	1748
P15	478	1567	P15	522	1711
P10	465	1525	P10	507	1664
P05	446	1462	P05	486	1595

Discussion

The Six Minute Walk Test (6MWT) has been shown to be a reliable and valid test of cardiovascular fitness in the elderly.[3,10] It is also used in individuals with cardiopulmonary disease, cystic fibrosis, and other conditions as a guide to the progression or deterioration of their condition.[11] Understanding and knowing baseline values for the six minute walk for children may provide important data on healthy children. It may also be important to be able to compare the values for children with disabilities to normative values for healthy children of their age.

For typical children, normative values of the 6MWT may help to better understand their health and possible risk factors for disease. Since this is a test of cardiovascular fitness, using this test on children in the schools may give the physical education teachers a better idea of which children may be in danger of developing diseases later in life. By intervening through the increase of physical activity, children may develop more healthy lifestyles that may stay with them throughout adulthood.

The 6MWT may be a good test to use for children for many reasons. It is easy to administer, which should allow anyone in the school to perform this test. It is also cost-effective and involves minimal materials or equipment. The 6MWT takes little to administer. It is also an easy test for the children to perform. Walking is a normal, everyday activity and most children walk at least 6 minutes during the day so it is not necessary to practice the test before testing.

The 6MWT has been determined to be a submaximal test of cardiovascular fitness.[11] Submaximal tests are more appropriate than maximal tests for testing children because it is rare that children ever exert a maximal effort during their daily lives. It may also be less taxing on the heart and body, so children with cardiovascular conditions or conditions that decrease cardiovascular performance should be able to perform this test. It will not put too much demand on the body, so there are few risks involved.

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

The 6MWT has been shown to predict morbidity and mortality in the elderly. By testing children early in their lives, it might be possible to intervene and prevent further complications. Children who are determined to be at risk for weight-related diseases could be entered into programs that increase their physical activity and by doing so, reduce their risk.

Body Mass Index (BMI) is a common way to classify an individual as being overweight or obese. [14] It has been accepted by the World Health Organization and the Center for Disease Control as a method to measure adiposity. [20] It is a simple, non-invasive screening tool requiring only two measurements: a person's height in meters and their weight in kilograms. An individual's BMI score can then be used to classify them normal, overweight, or obese. Overweight has been defined as having a BMI of 25-29 kg/m^2, and obese has been defined as having a BMI greater than or equal to 30 kg/m^2. The BMI has been used as a screening tool for indicating an individual's weight-related health risks such as stroke, cardiovascular disease, and diabetes mellitus, among others.

The BMI-for-age is a tool used for children ages 2 to 20 years since a child's BMI changes as they grow.[20] The BMI-for-age is used for examining weight-for-stature, as a child's weight, stature, and age are all accounted for on the same chart. BMI-for-age in childhood has been shown to predict adult BMI and the associated weight-related health risks. The Bogalusa Heart Study found that 60% of children ages 5 to 10 who were classified as being overweight had at least one clinical or biochemical risk factor for developing cardiovascular disease. Another 20% had two or more risk factors. BMI-for-age does relate to health risks and it is important to examine a child's weight-for-stature to predict their risks as adults.[20]

Generally, the guidelines for administering the test were used from the test manual of the AAHPERD lifetime Health Related Physical Fitness Test for the nine-minute walk-run test.[21] These guidelines were adopted for this study as they were more suitable for the subjects. The American Thoracic Society developed guidelines for administering the 6MWT.[22] These guidelines were developed to insure the safety of patients during testing. Many of these guidelines were not appropriate for the subjects in this study. However, the clinician should review these guidelines if the test is administered to a subject with significant health conditions.

This study was limited by several factors. When instructed to walk, some of the children ran, skipped, and galloped. The investigators continually monitored the children and reminded them to walk. Subjects were asked to stop immediately when the time ended. Some students may have taken extra steps after they were instructed to stop. Some of the subjects may have traded or dropped their straws without the knowledge of the investigators even though instructed not to. A standard stopwatch was used to keep time and was assumed to be accurate. A standard tape measure was used to measure the distance walked and was assumed to be accurate. A standard bathroom scale was calibrated, used to measure weight, and was assumed to be accurate. The researchers had little control over the behaviors and motivation levels of the subjects. During data collection, other classes were outside for recess and physical education classes and may have caused a distraction to the subjects participating in this study.

Another limitation was that the data were not collected from a wide area across the country, but only the Phoenix metropolitan area and at only two schools. It was very difficult to recruit schools to participate because of concerns about the use of children in research studies. However, the two schools that participated were very pleased with the activities and the overall benefit the results may have in assessing fitness in children. The sample sizes may be criticized as a limitation. However, the data fit the normal distribution, indicating that the sample was a good representation of the population. Therefore, a larger sample size would not have provided more information. However, it would be beneficial to include a larger sample as this may allow for the development of confidence intervals for each percentile.

Summary

There is no relationship between distance walked and BMI. This study should be repeated with children of other ages to determine normative values for all ages. Since the purpose of the current study was to determine baseline values for the 6MWT in healthy, third-grade children, it is recommended that future studies compare these values to those of the performance for special populations.

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