Assessment of Physical Performance in Adolescents of Varying Body Weight

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ASSESSMENT OF PHYSICAL PERFORMANCE IN ADOLESCENTS OF VARYING BODY WEIGHT

BY

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NICOLE LIQUORI

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A capstone project submitted to the Graduate Faculty in Physical Therapy in partial fulfillment of the requirements for the degree of Doctor of Physical Therapy (DPT), The City University of New York

2015
This manuscript has been read and accepted for the Graduate Faculty in Physical Therapy in satisfaction of the capstone project requirement for the degree of DPT.

Maureen Becker, PT, DHsc

________________________
Date

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Chair of Examining Committee (Advisor)

Jeffrey Rothman, PT, Ed.D.

________________________
Executive Officer

THE CITY UNIVERSITY OF NEW YORK
ABSTRACT

ASSESSMENT OF PHYSICAL PERFORMANCE IN ADOLESCENTS OF VARYING BODY WEIGHT

BY

NICHOLAS DALONZO

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NICOLE SAVARESE

ADVISOR: MAUREEN BECKER PT, DHSc

Fifty-one healthy adolescents of both gender without any neuromuscular, musculoskeletal or cardiopulmonary disorders and between the ages of 12 and 17 with a mean age of 14.09 years (SD: 1.45 years) were recruited to participate in the 6-minute walk test. Several measurements such as height, weight and leg length were taken before testing, along with heart rate, blood pressure and oxygen saturation (SPO2) before, after and 10 minutes post 6-minute walk test. Walk distance was also quantified and used as an outcome measure. The adolescents were divided into two groups prior to statistical testing. The first group was classified as the “normal” weight group (n=41) and were characterized as normal if their body mass index (BMI) percentile was less than 85%. The second group was classified as the “overweight” weight group (n=10) and were characterized as overweight if their body mass index percentile was over 85%. Results from a multivariate regression analysis (OLS) suggest there is a significant, negative relationship between body mass index (BMI) and walk distance when controlling for leg length and age in the sample. The same statistical analysis indicates a significant, positive relationship between leg length and walk distance, controlling for BMI and age. An analysis of variance was performed for this study in order to investigate if there was any significance in change of blood pressure,
SPO2 and heart rate over the three trials between the overweight and normal BMI groups. These tests revealed no significance in performance or change in vital sign between the two groups. Based on our results, we conclude that the 6-minute walk test can be used as a reliable assessment of physical fitness in the adolescent population.
ACKNOWLEDGEMENTS

Dr. Maureen Becker, PT, DHSc for her guidance and mentorship through the past three years in the research section of the doctor of physical therapy program at the College of Staten Island. Dr. Maria Knikou and Dr. Jean Berteau for their time, resources, and willingness to help in the current study. All participants for their involvement and cooperation in our research.
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INTRODUCTION

Physical fitness and performance are essential to an individual’s health and well-being. The ability to efficiently carry out the activities of daily life is essential in evaluating physical performance and predicting the likelihood of illness in the future (Li et. al 2006). Anthropometric factors may impair these capabilities (Hikes et. al 2003). Obesity can be identified as one of the foremost problems encountered by individuals across the United States. This has become a widespread problem and can be identified as an epidemic. According to the center for disease control, “The percentage of children aged 6–11 years in the United States who were obese increased from 7% in 1980 to nearly 18% in 2012. Similarly, the percentage of adolescents aged 12–19 years who were obese increased from 5% to nearly 21% over the same period.” (Centers for Disease Control and Prevention). Sedentary behaviors have proven to be indicative of musculoskeletal stress and systemic disorders that are debilitating and ultimately life-threatening (Li et. al 2006). A great deal of effort has been placed into combating this growing problem, beginning with children and adolescents. Children with a high body mass index and low physical performance often demonstrate elevated cholesterol counts and high blood pressure, transitioning into obese adults at increased risk for diabetes, cardiovascular disease and certain cancers (Ogden et. al 2011).

Evaluating the levels of exertion for daily activities serves as a reflection of physical capability. Submaximal exercises, such as walking, serve useful in assessment of healthy function (Li et. al 2005). The 6-minute walk test was found to be a valid and reliable functional test in assessing exercise tolerance and endurance in healthy children (ages 12-16) from China (Li et. all 2005). Overweight children and adolescents demonstrated variability in performances on the 6-minute walk test, particularly 6-minute walking distance (Calders et. al 2008). The
sample population for this study, however, did not take into account weight as a determining factor for performance. Additionally, 6-minute walk test values for children found in other countries may not be applicable to children in the United States (Klepper and Muir 2011). Many studies have been conducted utilizing individuals from the United States, testing children from age 7-11 (Klepper and Muir 2011) or strictly with adult populations, finding that the 6-minute walk distance and heart rate were lower in the obese population as opposed to the “normal” population (Klepper and Muir 2011). Research has yet to be done regarding the adolescent population from ages of 12-17. The exercise behaviors and dietary habits of individuals in this age group often determine physical performance and health in adulthood (Ogden et al. 2011). The results yielded from this population using the six-minute walk test may have served as valuable information in identifying young adults who may be at risk for future disease related to and/or secondary to obesity.

The objective of this study will determine to what extent the 6-minute walk test could differentiate levels of fitness in adolescent aged children of various body masses and anthropometric measures. We hypothesize that adolescents with larger body mass index measurements (overweight and obese) will have lower walk distance totals than those of normal/healthy weight adolescent participants. We also anticipate that overweight and obese adolescents will report greater exertion scores on the Omni Perceived Exertion Scale (Utter et. al 2002). We expected for there to be a positive relationship between the participants’ leg lengths with overall walk distance. Age would also affect performances in the 6-minute walk test, as we hypothesized that older children will yield higher walking distances in their testing. In addition, we expect that baseline, post-test and ten-minute post test scores within the two groups to be
different. We expect blood pressure and heart rate to increase with exertion, while oxygen saturation will decrease following testing.

METHODS

Participant Characteristics

Fifty-one healthy male and female adolescents between the ages of 12 and 17 (mean: 14.09 years, SD: 1.45 years) without any neuromuscular, musculoskeletal or cardiopulmonary disorders were recruited to participate in this study. All experimental procedures were conducted according to the Declaration of Helsinki. The experimental protocol of this study was approved by the Institutional Review Board (IRB) of the City University of New York Graduate Center. Exclusion criteria outlined in the protocol included those unable to provide consent or assent, pregnancy, hospital admission in the past six months, serious medical conditions such as seizures and orthopedic conditions/surgeries within the past six months and no serious pathologies of the following systems: cardiovascular (high blood pressure, arrythmias), neuromuscular (cerebral palsy, stroke), musculoskeletal (sprains, strains, lower extremity fractures within the last 6 months) and respiratory (asthma, cystic fibrosis).

Justification for Sample Size

This is a preliminary study and preliminary data is not available to establish the power sample size of the subjects. We decided to recruit the minimal number of participants. For example, a recent study published in 2011 which investigated reference values for the 6-minute walk test (6MWT) and the relationship between 6-minute walk distance (6MWD) and age, sex, and anthropometric variables in children who are healthy, aged 7 to 11 years and living in the United States (Klepper and Muir 2011), utilized a sample population of 100 children, (57
females and 43 males). Another study that sought to identify the predictors of distances achieved during the 6-minute walk test and the 12-minute walk test in obese children recruited sixty-five (Calders et. al 2008). One experiment analyzed predictors of the 6-minute walk test in lean, obese, and morbidly obese women, utilizing 85 participants. The number of subjects was found to be sufficient for significant findings in this work (Hikes et. al 2003). This sample size quota has proven valid and reliable in attaining significant results in multiple studies of both children and adults.

**Experimental Protocol**

Each subject and their parent and/or guardian signed an assent and informed consent form, respectively. Each adolescent was asked to complete a pretest self-reported physical activity questionnaire to gauge their activity levels in everyday life. After all the initial paperwork was completed, measurements were taken to quantify the subject’s anthropometric characteristics. Picture 1 illustrates how the height was measured via a tape measure on the wall to the nearest tenth of an inch. Weight was measured on a digital scale to the nearest tenth of a pound. Leg length was measured by a tape measure to the nearest tenth of an inch. This procedure can be seen in Picture 2. Each participant was then be taken into an isolated hallway to sit in a chair for 10 minutes completely at rest. The resting heart rate, blood pressure and pulse oximetry measures were taken before, immediately after and 10 minutes post 6-minute walk test. Pictures 3 and 4 depict the recording of these vital signs before activity was initiated. Blood pressure was taken using a digital blood pressure monitor by the same researcher for all subjects. Heart rate and SPO2 was measured with a pulse oximeter. Instructions were given/explained to each participant individually as per the 6-minute walk test protocol guidelines by the American Thoracic Society (ATS 2002). The Omni Perceived Exertion scale and the aforementioned
measurements were also taken immediately after the 6-minute walk test and 10 minutes post-test. Picture 5 shows the scale used in this study. Body mass index (BMI in kg/m²) was calculated using the National Centers for Disease Control (CDC) growth charts based on height and weight. The subject was identified by an assigned number and not their name to protect the subject's privacy. All measurements, questionnaires and demographic information is kept privately in the numbered file which is kept in a locked file cabinet in the Principal Investigator’s office.

Picture 1: The height of the subject is being measured using a tape measure mounted on the wall (in inches).
Picture 2: The leg length of the subject is measured from anterior superior iliac spine (ASIS) to medial malleolus using a tape measure (in inches).

Picture 3: Blood pressure measurements are taken before the 6-minute walk test using a digital blood pressure monitor.
Picture 4: Resting heart rate and oxygen saturation (SP02) are recorded using a digital pulse oximeter.

Picture 5: The Omni Perceived Exertion Scale show immediately after the 6-minute walk test.
6-Minute Walk Test Protocol

Two cones were placed in an isolated hallway at a distance of 100 feet apart. Picture 6 shows the subject in the hallway walking from cone to cone. Before the participant began, specific instructions were given according to the American Thoracic Society's (ATS) guidelines. They are as follows:

The objective of this test is to walk as far as possible for 6 minutes. You will walk back and forth in this hallway. Six minutes is a long time to walk, so you will be exerting yourself. You may get out of breath or become exhausted. You are permitted to slow down, to stop, and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you are able. You will be walking back and forth around the cones. You should pivot briskly around the cones and continue back the other way without hesitation. Now I’m going to show you. Please watch the way I turn without hesitation.” Demonstrate by walking one lap yourself. Walk and pivot around a cone briskly. “Are you ready to do that? I am going to use this counter to keep track of the number of laps you complete. I will click it each time you turn around at this starting line. Remember that the object is to walk AS FAR AS POSSIBLE for 6 minutes, but don’t run or jog. Start now, or whenever you are ready.”

As soon as the participant begins to walk the timer will start. The only talking that should occur during the walk is standard phrases of encouragement in an even tone voice as per the Guidelines. They are:

1. After the first minute, tell the participant the following (in even tones): “You are doing well. You have 5 minutes to go.”

2. When the timer shows 4 minutes remaining, tell the participant the following: “Keep up the good work. You have 4 minutes to go.”
3. When the timer shows 3 minutes remaining, tell the participant the following: “You are doing well. You are halfway done.”

4. When the timer shows 2 minutes remaining, tell the participant the following: “Keep up the good work. You have only 2 minutes left.”

5. When the timer shows only 1 minute remaining, tell the participant, “You are doing well. You have only 1 minute to go.”

6. When the timer is 15 seconds from completion, say this: “In a moment I’m going to tell you to stop. When I do, just stop right where you are and I will come to you.”

Do not use other words of encouragement (or body language to speed up). If the participant stops walking during the test and needs a rest, say this: “You can lean against the wall if you would like; then continue walking whenever you feel able.” Do not stop the timer. If the participant stops before the 6 minutes are up and refuses to continue (or you decide that they should not continue), wheel the chair over for the participant to sit on, discontinue the walk, and note on the worksheet the distance, the time stopped, and the reason for stopping prematurely.

When the timer rings, one investigator will say, “Stop!” and will then walk over to the participant. The spot where they stop will be marked by placing a piece of tape on the floor. The participant will be given a chair to sit and one investigator will administer the Omni Perceived Exertion Scale, followed by repeat measures of heart rate, blood pressure and oxygen levels. The other investigator will measure the walk distance. Once repeat measurements are complete the investigator will ask the participant, “What, if anything, kept you from walking any further?” The participant will be congratulated on a good effort and will be offered a drink of water. The participant will sit for 10-15 minutes until all vital signs (heart rate, blood pressure and oxygen levels) return the resting levels.
RESULTS

The first analytical approach that was utilized addressed the entire sample population, regardless of BMI grouping. Each of the aforementioned experimental variables were analyzed using correlational analysis to establish a causal relationship with our variable of interest, that being 6-minute walk distance. Each individual explanatory variable was correlated to 6-minute walk distance using a multivariate linear regression model. This determined the influence of each variable on 6-minute walk distance while controlling for all other variables.

The next sequence of analytical findings sought to establish between group differences where the sample (n=51) was divided into two groups based on BMI percentile rankings. The first group consisted of those who were less than or equal to the 85th percentile according to the National Centers for Disease Control (CDC) growth charts based on height, weight and age (n=41). These individuals were all considered normal weight and below normal weight for their
specific age range. The second group consisted of those who were greater than or equal to the 85th percentile for their specific age group, labeling them either overweight or obese for their specific age range (n=10).

Table 1 displays descriptive statistics collected from the sample (n=51) for this study.

**Table 1: Descriptive statistics for walking distance (dependent variable) and age, weight, height, leg length, OMNI, BMI and BMI percentage (independent variables).**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking distance (ft.)</td>
<td>1,693</td>
<td>264.3</td>
<td>1,163</td>
<td>2,203</td>
<td>51</td>
</tr>
<tr>
<td>Age</td>
<td>14.1</td>
<td>1.4</td>
<td>12</td>
<td>17</td>
<td>51</td>
</tr>
<tr>
<td>Weight (lbs.)</td>
<td>126.2</td>
<td>31.1</td>
<td>80</td>
<td>229.5</td>
<td>51</td>
</tr>
<tr>
<td>Height (in.)</td>
<td>63.6</td>
<td>3.9</td>
<td>56</td>
<td>70.5</td>
<td>51</td>
</tr>
<tr>
<td>Leg length (in.)</td>
<td>35</td>
<td>2.3</td>
<td>31</td>
<td>41</td>
<td>275</td>
</tr>
<tr>
<td>OMNI</td>
<td>1.1</td>
<td>1.2</td>
<td>0</td>
<td>6</td>
<td>51</td>
</tr>
<tr>
<td>BMI</td>
<td>21.7</td>
<td>3.9</td>
<td>16.8</td>
<td>35.9</td>
<td>51</td>
</tr>
<tr>
<td>BMI (%)</td>
<td>63.9</td>
<td>23.6</td>
<td>16</td>
<td>95</td>
<td>51</td>
</tr>
</tbody>
</table>

Some further exploratory data analysis was also conducted to prior to adopting a multivariate linear regression approach to better understand the relationships that the independent variables yielded on 6-minute walk distance and performance. Correlations were established between paired samples using Pearson’s product moment correlation coefficient. Figure 1 (a-f) shows the relationship between each of these independent variables and 6-minute walk distance. The red lines represent the line of best fit between both sets of variables and the slope of the line provides an indication of the relationship.
**Figure 1**: Correlation between 6-minute walk distance and independent variables.

The findings from this multivariate analysis suggest that only BMI (e) is significantly correlated with 6-minute walk distance \(r = -0.292, p\text{-value} < 0.05\). This finding is consistent with our hypothesis, stating that individuals with higher BMIs would not have greater 6-minute walk distances than those with lower BMI values. The results of all other linear regressions, although insignificant, were consistent with our hypotheses. The basic trend and directionality of the other independent variables supported our assertions. Positive relationships were established for height (c) and leg length (d). Subjects of greater heights and leg length were shown to
perform better in the 6-minute walk test, yielding greater 6-minute walk distances than those who were shorter and had smaller leg length measurements. The negative relationship between weight and 6-minute walk distance (b) was also consistent with our hypothesis. One variable was contradictory to our initial predictions, that being the assertion that subjects who were older would walk further than younger participants in the study (a). A negative relationship was established regarding these paired samples.

Finally, a multivariate regression approach, Ordinary Least Squares (OLS), was utilized to more explicitly test the contribution of each individual variable to 6-minute walk distance. In multivariate frameworks one possibly problem for modeling is multicollinearity. Multicollinearity refers to the statistical occurrence of explanatory variables being correlated with other independent variables in a multivariate regression context, which can increase variance in coefficient estimates; this makes the resulting coefficients unstable and difficult to interpret (Farrar and Glauber 1967). For example, height and leg length will be highly correlated, and weight and BMI will also be highly correlated. In view of this concern, Variance Inflation Factors (VIF) were calculated to measure the extent to which correlation among the explanatory variables inflates the variance of the estimated regression coefficients in each of the models. The general rule of thumb is that VIFs greater than 10 indicate excessive multicollinearity requiring correction (Kutner et al. 2005). In the first instance (Model A), all explanatory variables were included in the model results for this are seen in Table 2.
Table 2. (Model A) Ordinary Least Squares of walk distance. Correlation coefficients.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t</th>
<th>p-value</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-3.28</td>
<td>-0.985</td>
<td>0.330</td>
<td>1.8</td>
</tr>
<tr>
<td>Weight (lbs.)</td>
<td>-14.7</td>
<td>-0.815</td>
<td>0.419</td>
<td>255.8</td>
</tr>
<tr>
<td>Height (in.)</td>
<td>54.1</td>
<td>0.739</td>
<td>0.464</td>
<td>68.1</td>
</tr>
<tr>
<td>Leg length (in.)</td>
<td>37.4</td>
<td>0.891</td>
<td>0.378</td>
<td>7.6</td>
</tr>
<tr>
<td>OMNI</td>
<td>-9.4</td>
<td>-0.311</td>
<td>0.758</td>
<td>1.1</td>
</tr>
<tr>
<td>BMI</td>
<td>70.3</td>
<td>0.592</td>
<td>0.557</td>
<td>4.9</td>
</tr>
<tr>
<td>BMI (%)</td>
<td>-1.1</td>
<td>-0.324</td>
<td>0.748</td>
<td>180.5</td>
</tr>
</tbody>
</table>

Overall the model results (F-statistic: 1.882 on 7 and 43 DF, p-value: 0.0962) suggest that these independent variables are not significant predictors of walking distance. Furthermore, the independent variables only explain roughly 11% of the variance in walking distance (Adjusted R-squared=0.109). Finally, when examining the VIFs associated with the variables it is clear that multicollinearity is problematic with weight, height, and BMI (%) all having values far greater than 10, the accepted cut-off.

A second model (Model B) that included only of those variables with VIFs less than 10 proved a far better fit for the data.

Table 3. (Model B) Ordinary Least Squares of walk distance. Correlation coefficients.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t</th>
<th>p-value</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-25.33</td>
<td>-0.990</td>
<td>0.327</td>
<td>1.5</td>
</tr>
<tr>
<td>Leg length (in.)</td>
<td>33.3</td>
<td>2.145</td>
<td><strong>0.037</strong></td>
<td><strong>1.1</strong></td>
</tr>
<tr>
<td>OMNI</td>
<td>-8.8</td>
<td>-0.310</td>
<td>0.757</td>
<td>1.0</td>
</tr>
<tr>
<td>BMI</td>
<td>-24.4</td>
<td>-2.73</td>
<td><strong>0.008</strong></td>
<td><strong>1.0</strong></td>
</tr>
</tbody>
</table>
Overall model results (F-statistic: 3.292 on 4 and 46 DF, p-value: 0.0187) suggest that these explanatory variables are significant predictors of 6-minute walk distance. Despite dropping independent variables in Model B, there is an overall increase in the explained variance in 6-minute walk distance (Adjusted R-squared=0.155). These four variables explain roughly 15.5% of the 6-minute walk distance outcome for our sample. In addition, both BMI and leg length as significant predictors of walking distance and consequently can be interpreted for their independent influence on walking distance while controlling the other explanatory variable. For example, for every additional inch in leg length a participant will walk an additional 33.3 feet. While, the relationship between BMI and walking distance is the opposite. More specifically, for each additional BMI number participants will walk 24.4 feet less during the six-minute walk test when holding the other variables such as age, leg length and OMNI constant.

The second set of analyses required the sample be split into two groups based on the BMI percentage of each participant. Table 4 provides new descriptive statistics for the two groups.
Table 4: Descriptive statistics different BMI categories (Group 1 <85% and Group 2 > 85%).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean 1</th>
<th>Std. Dev. 1</th>
<th>Min 1</th>
<th>Max 1</th>
<th>Mean 2</th>
<th>Std. Dev. 2</th>
<th>Min 2</th>
<th>Max 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking distance (ft.)</td>
<td>1,724</td>
<td>1,566</td>
<td>255.41</td>
<td>275.7</td>
<td>1,163</td>
<td>1,174</td>
<td>2,203</td>
<td>2,169</td>
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<tr>
<td>Age</td>
<td>14.1</td>
<td>1.4</td>
<td>12</td>
<td>17</td>
<td>12</td>
<td>17</td>
<td>17</td>
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<tr>
<td>Weight (lbs.)</td>
<td>117.2</td>
<td>21.2</td>
<td>80</td>
<td>169.5</td>
<td>229.5</td>
<td>108</td>
<td>169.5</td>
<td>229.5</td>
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<tr>
<td>Height (in.)</td>
<td>63.6</td>
<td>4.1</td>
<td>56</td>
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<td>Leg length (in.)</td>
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<td>OMNI</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>BMI</td>
<td>20.2</td>
<td>1.9</td>
<td>16.8</td>
<td>24</td>
<td>35.9</td>
<td>82</td>
<td>24</td>
<td>35.9</td>
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<tr>
<td>BMI (%)</td>
<td>56.8</td>
<td>20.8</td>
<td>16</td>
<td>83</td>
<td>95</td>
<td>83</td>
<td>83</td>
<td>95</td>
</tr>
<tr>
<td>n</td>
<td>41</td>
<td>10</td>
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</tr>
</tbody>
</table>

These descriptive statistics help to identify differences that exist between the two groups. For instance, on average those in Group 1 (those with BMIs less than 85%) walk farther than those from Group 2 (those with BMIs greater than 85%). However, descriptive statistics do not enable inferences to be drawn. In other words, this difference may be the result of a random process and consequently there is no real difference between the groups. To test the hypotheses that differences exist between these two groups for each of these variables requires inferential statistical tests. Ideally when conducting research you have two groups of equal sizes to test as this helps to minimize the number of potential distributional assumptions that must be met when using any number of parametric statistical tests. In reality however this is often not possible and so researchers must rely on a different set of techniques that require fewer, and in some instances, no distributional assumptions. For example, if we had two groups of twenty-five subjects that fit into the below 85% and above 85% we could use a Student’s t-test and be fairly
confident of our results. However, because our sample sizes may not meet the stringent assumption of normality, and relative equality in sample size and variances (or standard deviation) we cannot be certain that the results will be robust against the homogeneity of variance assumption required to be confident that results from a Student’s t-test will be correct.

Permutation tests represent one approach to overcoming this problem. Permutation tests free us from the stringent assumption of normality and equal variances because there are few distributional assumptions. In our case, we would like to know if differences exist between the two groups and so by assuming the null hypothesis is true we can randomly permute (exchange or shuffle) data between both samples. Rather than permuting every combination between samples we can use a Monte Carlo simulation to approximate the likely $p$-value and determine if there is a real systematic difference between groups or the difference is the result of random chance. Because there is an anticipated direction of effect in some instances, e.g. Group 1 is expected to have, on average, walked farther than Group 2 single-tailed tests were used to more accurately measure this expectation. Table 5 provides the results for the difference in means test (t-test) for the two groups.
Table 5. Difference in means (t-test) non-parametric permutation test.

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
<th>Tested direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking distance (ft.)</td>
<td>0.045</td>
<td>Group 1 &gt; Group 2</td>
</tr>
<tr>
<td>Age</td>
<td>0.803</td>
<td>Group 1 ≠ Group 2</td>
</tr>
<tr>
<td>Weight (lbs.)</td>
<td>0.000</td>
<td>Group 1 &lt; Group 2</td>
</tr>
<tr>
<td>Height (in.)</td>
<td>0.966</td>
<td>Group 1 ≠ Group 2</td>
</tr>
<tr>
<td>Leg length (in.)</td>
<td>0.644</td>
<td>Group 1 ≠ Group 2</td>
</tr>
<tr>
<td>OMNI</td>
<td>0.274</td>
<td>Group 1 &lt; Group 2</td>
</tr>
<tr>
<td>BMI</td>
<td>0.000</td>
<td>Group 1 &lt; Group 2</td>
</tr>
<tr>
<td>BMI (%)</td>
<td>0.000</td>
<td>Group 1 &lt; Group 2</td>
</tr>
</tbody>
</table>

Note: Significant differences are in bold.

An analysis of variance was established between groups in order to establish significance between anthropometric measurements taken at baseline, post-test and 10 minutes post-test. This statistical measure was used to investigate whether there was significant change in these variables when comparing the overweight and obese group to the normal weight adolescent population.
Figure 2: Comparative means of heart rate data at baseline, post-test, and 10 min post-test.

As seen in the chart above, as well as a one way ANOVA, we found there to be no statistical significance between and within groups in relation to heart rate at baseline, post-test and 10 min post-test.

![Mean SPO2 Levels of Normal and Overweight Adolescents](image)

Figure 3: Comparative means of SPO2 at baseline, post-test, 10 min post-test.

As seen in the chart above, as well as a one way ANOVA, we found there to be no statistical significance between or within groups in relation to SPO2 at baseline, post-test, and 10 min post-test.
Figure 4: Comparative means of systolic BP at baseline, post-test, 10 min post-test.

As seen in the chart above, as well as a one way ANOVA, we found there to be no statistical significance between or within groups in relation to systolic blood pressure at baseline, post-test, and 10 min post-test.

Figure 5: Comparative means of diastolic BP at baseline, post-test, 10 min post-test.
As seen in the chart above, as well as a one way ANOVA, we found there to be no statistical significance between or within groups in relation to diastolic blood pressure at baseline, post-test, and 10 min post-test.

DISCUSSION

This study further solidifies previous research regarding use of the 6-minute walk test as a performance-based measure of functional exercise capacity in children ages (12-17). There is limited research using the age range of adolescent children from 12-17, making this study a beneficial component to future research on this topic. The results obtained did verify significant difference in 6–minute walk distance performance between normal weight and overweight/obese children. This significance was found in other studies and refutes other studies that did not identify any significant relationships between BMI and the 6-minute walk distance as supported by the work of Klepper and Muir (2011). This finding is intuitive and supports our initial hypothesis. Much of the research suggests overweight children require a large amount of energy demands when performing exercise when compared to normal weight children, therefore demonstrating decreased performance (Morinder et. al 2009). This study supports the findings yielded from our sample population.

Other experimental variables such as blood pressure, oxygen saturation and heart rate did not yield statistically significant results when compared across baseline, immediately post-test and ten minutes post-test. Overweight and normal weight adolescents have been shown to have different resting values for each of these measures. Overweight populations are believed to have higher responses to change in blood pressure and heart rate when performing the 6-minute walk test. Proof of this was given following a study with young Chinese children who showed positive
correlations between BMI and heart rate and blood pressure, particularly systolic heart rates (Chen et. al 2006). Many of our participants exhibited measurements that actually revealed lower blood pressure, oxygen saturation and heart rate after the 6-minute walk test. Several overweight subjects also revealed resting and post-test measurements that were lower than their normal weight contemporaries. These findings are refuted by a study conducted by Pathare, who found that children between the age of 5 and 9 and were overweight had a higher resting blood pressure and heart rate than their normal weight contemporaries. This study did find, however, that several of the overweight children had higher oxygen saturation rates when compared to normal weight children. This finding was consistent with our data, which found variation in resting and post exercise values for both weight groups (Pathare et. al 2012)

Several correlation analyses revealed relationships between co-variables tested. Linear regressions revealed that our data set represented several trends that could be applied to validate some of our initial hypotheses. Significance was found in the negative correlation between the 6-minute walk distance and BMI. Similar, non-significant, negative relationships can also be established between the 6-minute walk distance and weight, 6-minute walk distance and OMNI score and 6-minute walk distance and age. Participants generally demonstrated a decrease in 6-minute walk distance if they had a higher BMI, a greater weight, greater age and greater OMNI score. The only positive correlations that were found involved the relationship between 6-minute walk distance and both leg length and height. Significance was only found regarding leg length, though both leg length and height yielded similar trends. Individuals with greater leg lengths were found to walk greater distances. This finding was supported by previous literature in a study performed by Camarri et. al 2006 and Oliveirs et. al 2013 which found that older adults
and healthy children, respectively, with longer legs also produced greater 6-minute walk distances than those with shorter leg lengths.

There are several limitations and factors that may have contributed to our lack of statistical significance in differences between overweight and normal weight adolescents performing the 6-minute walk test. The first limitation lies in our inability to collect an equal number of normal weight and overweight adolescents for testing. When recruiting participants for this study, it was impossible to request or control the physical condition of the subjects. This study had a relatively large disparity between sample sizes with the normal group having 41 and the overweight group only having 10. This substantial difference may have skewed our results and the potential for gathering significant data comparing the two groups. Another limitation could be cited in our inability to control the activity levels, time of day when testing, eating habits and footwear choice of each adolescent in our study. Variability in these factors may have altered our results. A child that came from a grueling day at school or sport practice may have performed at less than optimal levels when undergoing performance testing. Meals immediately before performance may have decrease output as well and resulted in lethargy. Less than optimal footwear or walking attire could have played a substantial role in decreased performance.

Other factors may have also affected the data collection. Subject motivation stands out as the most likely cause of poor results. Despite the encouragement given during the test by the investigators, it is impossible to ensure that each participant is exerting the proper effort and performing to the best of their abilities. There may have been experimenter’s error in gathering information regarding vital signs, anthropomorphic measures and walk distances. Three different investigators performed these tasks, so it is likely there was some error in inter-rater reliability and consistency.
CONCLUSION

This study was designed to determine if the 6-minute walk test could be used as a predictor of physical performance in adolescents of varying body weights. The prominence of obesity in adolescent populations has skyrocketed over the past 30 years from nearly 8 million children to over 25 million. This growing trend must be assessed and addressed immediately. Early diagnosis is necessary in order to prevent and treat symptoms that may hinder a child’s development and predispose them to common adult comorbidities that are synonymous with adolescent obesity, such as diabetes, cardiovascular disease and osteoporosis. The 6-minute walk test and performance in this task may serve as an early diagnostic tool to combat progression of this ongoing epidemic. Further research is needed to standardize expected results involving the adolescent population. Developing predicting tools such as the 6-minute walk test could save the healthcare system in the long run by promoting wellness and physical fitness. Adolescent obesity may translate into the preserving of over 150 billion dollars annually, as well as saving countless lives in the process (Center for Science in the Public Interest 2012).
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