Chapter II

Review of the Related Literature
Chapter-II

REVIEW OF THE RELATED LITERATURE

OVERVIEW

2.1 Scientific Authenticity of Twelve Minute Run and Walk Test for Different Populations
2.2 Validation of Different Run/Walk Tests for Different Populations
2.3 Reviews on One Mile Jog Test
2.4 Effects of Run and Walk Exercise Programmes
2.5 Relationship among Cardiorespiratory Fitness, Physiological Parameters and Run and Walk Tests
2.6 Different Physiological Variables as Independent Variables and VO\textsubscript{2} Max as Dependent Variable
2.7 Reviews on Run/Walk Test as an Item in Fitness Test Battery
2.8 Reliability and Validity of Ratings of Perceived Exertion
2.9 Ratings of Perceived Exertion and Exercise Heart Rate
2.10 Relationship between Running / Walking and Ratings of Perceived Exertion
2.11 Other Related Studies
2.12 Summary of the Review of the Related Literature
2.13 Conclusions Drawn from the Review of the Related Literature
2.14 Essence of Reviews
Chapter-II

REVIEW OF THE RELATED LITERATURE

A scholarly attempt was made by the investigator to study the relevant literature and research pertaining to the study highlighting the several aspects, widening the horizon and body of knowledge on the subject.

2.1 Scientific Authenticity of Twelve Minute Run and Walk Test for Different Populations

Cooper \(^1\) conducted a study to determine Cardiorespiratory endurance during a 12- minute running or walking activity. His findings were as follows:

Table-5 (a.)

<table>
<thead>
<tr>
<th>Fitness Category</th>
<th>Gender</th>
<th>13-19</th>
<th>20-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior</td>
<td>Male</td>
<td>&gt;1.85</td>
<td>&gt;1.77</td>
<td>&gt;1.70</td>
<td>&gt;1.66</td>
<td>&gt;1.59</td>
<td>&gt;1.56</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>&gt;1.52</td>
<td>&gt;1.46</td>
<td>&gt;1.40</td>
<td>&gt;1.35</td>
<td>&gt;1.31</td>
<td>&gt;1.19</td>
</tr>
<tr>
<td>Excellent</td>
<td>Male</td>
<td>1.73-1.86</td>
<td>1.65-1.76</td>
<td>1.57-1.69</td>
<td>1.54-1.65</td>
<td>1.45-1.58</td>
<td>1.33-1.55</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.44-1.51</td>
<td>1.35-1.45</td>
<td>1.30-1.39</td>
<td>1.25-1.35</td>
<td>1.19-1.30</td>
<td>1.10-1.18</td>
</tr>
<tr>
<td>Good</td>
<td>Male</td>
<td>1.57-1.72</td>
<td>1.50-1.64</td>
<td>1.46-1.56</td>
<td>1.40-1.53</td>
<td>1.31-1.44</td>
<td>1.21-1.32</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.30-1.43</td>
<td>1.23-1.34</td>
<td>1.19-1.29</td>
<td>1.12-1.24</td>
<td>1.06-1.18</td>
<td>0.99-1.09</td>
</tr>
<tr>
<td>Fair</td>
<td>Male</td>
<td>1.38-1.56</td>
<td>1.32-1.49</td>
<td>1.31-1.45</td>
<td>1.25-1.39</td>
<td>1.17-1.30</td>
<td>1.03-1.20</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.19-1.29</td>
<td>1.12-1.22</td>
<td>1.06-1.18</td>
<td>0.99-1.11</td>
<td>0.94-1.05</td>
<td>0.87-0.98</td>
</tr>
<tr>
<td>Poor</td>
<td>Male</td>
<td>1.30-1.37</td>
<td>1.22-1.31</td>
<td>1.18-1.30</td>
<td>1.14-1.24</td>
<td>1.03-1.16</td>
<td>0.87-1.02</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.00-1.18</td>
<td>0.96-1.11</td>
<td>0.95-1.05</td>
<td>0.88-0.98</td>
<td>0.84-0.93</td>
<td>0.78-0.86</td>
</tr>
<tr>
<td>Very Poor</td>
<td>Male</td>
<td>&lt;1.30</td>
<td>&lt;1.22</td>
<td>&lt;1.18</td>
<td>&lt;1.14</td>
<td>&lt;1.03</td>
<td>&lt;0.87</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>&lt;1.0</td>
<td>&lt;0.96</td>
<td>&lt;0.94</td>
<td>&lt;0.88</td>
<td>&lt;0.84</td>
<td>&lt;0.78</td>
</tr>
</tbody>
</table>

Cooper proposed another norms where the performance need to be measured in meters. His findings are as following:

**Table-5 (b.)**

Norms of Twelve Minute Run and Walk Test (Distance in Meters) Proposed by Cooper to Estimate Cardiorespiratory Endurance of Selected Age Categories

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Very good</th>
<th>Good</th>
<th>Average</th>
<th>Bad</th>
<th>Very bad</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-14</td>
<td>M</td>
<td>2700+ m</td>
<td>2400 - 2700 m</td>
<td>2200 - 2399 m</td>
<td>2100 - 2199 m</td>
<td>&lt; 2100 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2000+ m</td>
<td>1900 - 2000 m</td>
<td>1600 - 1899 m</td>
<td>1500 - 1599 m</td>
<td>&lt; 1500 m</td>
</tr>
<tr>
<td>15-16</td>
<td>M</td>
<td>2800+ m</td>
<td>2500 - 2800 m</td>
<td>2300 - 2499 m</td>
<td>2200 - 2299 m</td>
<td>&lt; 2200 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2100+ m</td>
<td>2000 - 2100 m</td>
<td>1700 - 1999 m</td>
<td>1600 - 1699 m</td>
<td>&lt; 1600 m</td>
</tr>
<tr>
<td>17-20</td>
<td>M</td>
<td>3000+ m</td>
<td>2700 - 3000 m</td>
<td>2500 - 2699 m</td>
<td>2300 - 2499 m</td>
<td>&lt; 2300 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2300+ m</td>
<td>2100 - 2300 m</td>
<td>1800 - 2099 m</td>
<td>1700 - 1799 m</td>
<td>&lt; 1700 m</td>
</tr>
<tr>
<td>20-29</td>
<td>M</td>
<td>2800+ m</td>
<td>2400 - 2800 m</td>
<td>2200 - 2399 m</td>
<td>1600 - 2199 m</td>
<td>&lt; 1600 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2700+ m</td>
<td>2200 - 2700 m</td>
<td>1800 - 2199 m</td>
<td>1500 - 1799 m</td>
<td>&lt; 1500 m</td>
</tr>
<tr>
<td>30-39</td>
<td>M</td>
<td>2700+ m</td>
<td>2300 - 2700 m</td>
<td>1900 - 2299 m</td>
<td>1500 - 1899 m</td>
<td>&lt; 1500 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2500+ m</td>
<td>2000 - 2500 m</td>
<td>1700 - 1999 m</td>
<td>1400 - 1699 m</td>
<td>&lt; 1400 m</td>
</tr>
<tr>
<td>40-49</td>
<td>M</td>
<td>2500+ m</td>
<td>2100 - 2500 m</td>
<td>1700 - 2099 m</td>
<td>1400 - 1699 m</td>
<td>&lt; 1400 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2300+ m</td>
<td>1900 - 2300 m</td>
<td>1500 - 1899 m</td>
<td>1200 - 1499 m</td>
<td>&lt; 1200 m</td>
</tr>
<tr>
<td>50+</td>
<td>M</td>
<td>2400+ m</td>
<td>2000 - 2400 m</td>
<td>1600 - 1999 m</td>
<td>1300 - 1599 m</td>
<td>&lt; 1300 m</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2200+ m</td>
<td>1700 - 2200 m</td>
<td>1400 - 1699 m</td>
<td>1100 - 1399 m</td>
<td>&lt; 1100 m</td>
</tr>
</tbody>
</table>

Doolittle and Bigbee\(^2\) obtained a reliability coefficient of 0.94 for 12- minute run and walk performance with 133 junior high school boys as subjects. Correlations between relative VO\(_2\) max and the 12 minute run and walk and the 600 yard run and walk for nine boys were 0.90 and 0.62 respectively. Thus investigation concluded that the distance a junior high school boy can cover in 12 minutes is a reliable and valid indicator of his cardio vascular fitness; and, further, that it is more valid in this respect than the 600 yard test.

---

Dorociak \(^3\) conducted a study entitled as validity of running tests of 4, 8, and 12 minute’s duration in estimating aerobic power for college women of different fitness levels. Forty-eight females served as the subjects (N=17 beginning joggers, N=19 intermediate joggers and N= 12 track runners). Maximal oxygen consumption (VO\(_2\) max) was measured by standard open circuit spirometry as the subjects ran on the treadmill. The three distance runs took place on an indoor 220 yard track and were measured to the nearest meter. It was found that the 12 minute run had the highest correlation with VO\(_2\) max for the beginning runners. For the intermediate runners, any of the three distance runs can be used with equal confidence to estimate aerobic power. The 8 min run had the strongest relationship with VO\(_2\) max for the more advanced runners. When the data from all the groups were pooled, the correlation between VO\(_2\) max and the three runs were quite high and essentially the same (4-min r=0.86, 8 min run r=0.87 and 12-min run r=0.89).

Wanamaker \(^4\) conducted a study entitled as a study of the validity and reliability of the twelve minute run under selected motivational conditions. The objectives of the investigation were (1) to determine the validity of the twelve minute run under each of four selected motivational conditions; (2) to determine the validity of the twelve minute run under all conditions of administration; (3) to determine differences in twelve minute run performances among treatments under all conditions of test administration; (4) to determine the reliability of the twelve minute run under the four selected motivational conditions and (5) to determine the reliability of twelve minute run under all conditions of test administration.

Procedure: Ninety-six male students at West Texas State University between the ages of eighteen and twenty-three inclusive were classified in one of two categories: volunteer subjects or class subjects. Students who were volunteer subjects were selected or solicited from the campus at large. Those who were class subjects


were enrolled in one of two required physical education activity classes offered during the spring semester, 1969.

Subjects performed on a treadmill at a beginning speed of from 4 to 6 miles per hour on a 4 to 8 percent grade. After the initial run, the speed was increased by from ½ to 1 mile per hour and the grade increased by from 1 to 4 percent. An attempt was made to exhaust all subjects within three or four minute runs. Expired air was analyzed for oxygen consumption during the last two minutes of each of the three-minute runs.

After the laboratory measurements for each sub-group in the first test administration had been attained, one sub-group from each volunteer and each class cell was administered the twelve minute run test under a different motivational condition. One volunteer and one class cell ran individually, and one volunteer and one class cell ran as a group. The twelve minute run was repeated three days later, using the same procedure. Four days later, the twelve minute run was administered again, with volunteers who had run twice in a group running individually and volunteers who had run individually twice running in a group. This procedure was also followed for the class subjects.

**Results:** A difference was observed between the validity reported in the original twelve minute run study and the validity reported in this investigation. The predictive value of the twelve minute test in terms of maximum oxygen intake is doubtful under the conditions of this investigation because of the relatively high error estimates.

There was no significant difference between mean twelve minute run scores for volunteer and class subjects. The social facilitation effect produced no significant differences in individual or group treatments. The reliability coefficients found suggested reasonable relationships.

**Conclusions:** Based upon the conditions of this investigation, it was concluded that the twelve minute run was not an effective predictor of maximum intake of oxygen. The twelve minute run was considered a reliable measure. The social facilitation treatment (running in groups) and the conditions under which the twelve minute run was administered (volunteer or class subjects) were not effective in producing significantly different performances.
Iqbal and Ghosh\textsuperscript{5} conducted a study to review the Cooper's 12 minute run and walk test, on Indian sports persons in the age group of 14-18 years. The study was conducted on 136 male sports persons from non continuous endurance events like basketball, football, hockey and volleyball. The VO\textsubscript{2} max was evaluated in the laboratory on a computerized breath-by-breath analyzer following standard protocol and the predicted VO\textsubscript{2} max was also calculated from Cooper’s twelve minute run test. It was observed that the correlation coefficient of relative VO\textsubscript{2} max and 12 min run test of the present study was 0.76. A modified prediction equation was developed in the present study and was applied on a fresh group of 50 sports persons from non-continuous endurance events belonging to the same age group. The test-retest correlation was found to be 0.85 with SEE of 3.59. This denotes that the VO\textsubscript{2} max of the sports persons in the age group of 14-18 years can be predicted from 12 min run test with an accuracy of ±6.5 percent.

Bolonchuck\textsuperscript{6} investigated the accuracy of six minute run test to measure cardiorespiratory fitness. One hundred and twenty- five freshman students, assigned to two groups, were used for this study. Each subject completed both 12-minute and 6-minute jogging tests. The reliability of the test was established by comparing the two groups’ 12-minute test results. 6-minute test results were compared between the two groups, and there was no significant difference at the 0.1 level. The validity of the 12-minute test had previously been established ($r=0.90$); thus, the 6-minute test scores were compared with the 12- minute test scores. The result was $r=0.85$.

Drinkard et. al.,\textsuperscript{7} investigated the relationship between walk/run performance and cardiorespiratory fitness in adolescents who are overweight. Eight African-American adolescents (5 female, 3 male) and 10 Caucasian adolescents (5 female, 5 male) who were overweight (mean age=14.5 years, SD=2.0, range=12–17; mean body mass index [BMI] =42.9 kg/m\textsuperscript{2}, SD=11.5) participated in this study.

Methods: Subjects performed a 12-minute walk/run test. The distances travelled at both 9 minutes ($D_9$) and 12 minutes ($D_{12}$) were recorded, and the distance

\textsuperscript{5} R Iqbal and AK Ghosh, “Validation of Cooper’s 12 Minute Run Test for Estimation of Aerobic Capacity (VO\textsubscript{2} max)”, \textit{Indian Journal of Physiology and Allied Sciences} \textbf{53.4} (Oct, 1999): 164-71.
\textsuperscript{6} http://eric.ed.gov/ERICWebPortal/Home.portal?_nfpb=true&_pageLabel=Digitization
\textsuperscript{7} Drinkard et. al., “Relationships between Walk/Run Performance and Cardiorespiratory Fitness in Adolescents who are Overweight”, \textit{Physical Therapy} \textbf{81.12} (December, 2001):1889-1896.
travelled between 9 and 12 minutes (D_{9–12}) was calculated. Subjects also completed a maximal cycle ergometry test, during which peak oxygen uptake (VO_{2peak}), anaerobic threshold (AT), peak power (Wpeak), and power at the anaerobic threshold (W_{AT}) were determined. Body composition was determined by air displacement plethysmography.

Results: The mean percentage of body fat was 48.6% (SD=5.3%, range=40.3%–60.4%). Percentage of body fat and BMI were each inversely related to D_{9}, D_{12}, and VO_{2peak} (all \(P<.005\)). Peak oxygen uptake (\(r=.72, P=.0001\)), VO_{2peak} /kg lean body mass (\(r=.60, P<.005\)), Wpeak (\(r=.88, P<.0001\)), and W_{AT} (\(r=.72, P=.0007\)) were all related to D_{12}, with greater \(r\) values than for D_{9}. If D_{9–12} was included in regression analyses, D_{9} did not account for additional variance in any of the cycle ergometry variables.

Discussion and Conclusion: These results suggest that an easily obtained measurement of physical performance (distance travelled during a 12-minute walk/run test) is related to cardiorespiratory fitness and to body composition in adolescents who are overweight. The 12-minute walk/run distance is more predictive of cycle ergometry test results than the 9-minute distance.

Weisgerber et al.,\(^8\) evaluated Cooper’s twelve minute walk/run test as a marker of cardiorespiratory fitness in young urban children with persistent asthma.

Objective: To evaluate Cooper’s 12-minute run/walk test (CT12) as a one-time estimate of cardiorespiratory fitness and marker of fitness change compared with treadmill fitness testing in young children with persistent asthma.

Design: A cohort of urban children with asthma participated in the asthma and exercise program and a subset completed pre- and post- intervention fitness testing.

Participants: Forty-five urban children with persistent asthma aged 7 to 14 years participated in exercise interventions. A subset of 19 children completed pre- and post-intervention exercise testing.

Interventions: Participants completed a 9-week exercise program where they participated in either swimming or golf 3 days a week for 1 hour. A subset of

---

participants completed fitness testing by 2 methods before and after program completion.

**Main Outcome Measures:** CT12 results (meters), maximal oxygen consumption (VO₂\textsubscript{max}) \((\text{mL·kg}^{-1}·\text{min}^{-1})\), and treadmill exercise time (minutes).

**Results:** CT12 and maximal oxygen consumption were moderately correlated (pre-intervention: 0.55, \(P = 0.003\); post-intervention: 0.48, \(P = 0.04\)) as one-time measures of fitness. Correlations of the tests as markers of change over time were poor and insignificant.

**Conclusion:** In children with asthma, CT12 is a reasonable one-time estimate of fitness but a poor marker of fitness change over time.

Grant, Corbett, Amjad, Wilson, and Aitchison\(^9\) conducted the study with the aim to compare the results from a Cooper walk run test, a multistage shuttle run test, and a submaximal cycle test with the direct measurement of maximum oxygen uptake on a treadmill. Three predictive tests of maximum oxygen uptake- linear extrapolation of heart rate of VO₂ collected from a submaximal cycle ergometer test (predicted L/E), the Cooper 12 minute walk, run test, and a multi-stage progressive shuttle run test (MST) were performed by 22 young healthy males [mean (s.d.) - age 22.1 (2.4) years and body mass 72.4 (8.9) kg] and the values compared to those obtained by direct measurement on a maximal treadmill test. All of the subjects were regular exercisers. The mean (s.d.) from the various tests in ml.kg.\(^{-1}\)min.\(^{-1}\) were as follows: treadmill 60.1(8.0), Cooper 60.6(10.3), MST 55.6(8.0), and predicted L/E 52.0(8.4). The Cooper test had a correlation with the treadmill test of 0.92, while the MST and the predicted L/E had correlations of 0.86 and 0.76 respectively. Both the MST and predicted L/E showed systematic under prediction of the treadmill value. On average, the MST was 4.5 ml.kg.\(^{-1}\)min.\(^{-1}\) (s.d. 0.9) lower than the treadmill VO₂ max while the predicted L/E was 7.8 ml.kg.\(^{-1}\)min.\(^{-1}\) (s.d. 1.4) lower than the treadmill VO₂ max. These findings indicate that, for the population assessed, the Cooper walk run test is the best predictor of VO₂ max among the three tests.

Tsai\textsuperscript{10} conducted a study to determine the relationship between physical fitness and maximal work capacity, professional activity skill level, and scholastic aptitudes of physical education majors. The major problems were: (1) to determine interrelationships among selected commonly accepted physical fitness tests variables (2) to explore the possibility of adequately predicting the maximal aerobic capacity from the test items and (3) to identify relationships between physical fitness, professional activity skill activity and scholastic aptitudes of undergraduate male physical education major students.

One hundred and twenty students were used as subjects during 1968 to 1970 for test items including dips, sit-ups, weight, 300 yard run, 12 minute run and maximal aerobic capacity (old data), and thirty five additional subjects were used during the year of 1971 for the same test items (new data). All physical fitness variables intercorrelated significantly ($p \leq 0.05$) except VO$_2$ max and dips. Test-retest reliability of the variables was significant at 0.01 level. VO$_2$ max can be adequately predicted ($R^2 \geq 0.50$) in physical education majors from dips, weight, sit-ups and 12 minute run, with 12 minute run the best single predictor. There is a significant but low relationship between physical fitness and specific sport skill in professional activity (based upon ratings by experts). There were no relationships between physical fitness scholastic aptitude and professional activity skill based upon ratings by experts.

Taylor\textsuperscript{11} predicted the maximal oxygen uptake of young females using selected submaximal estimators. A sample of twenty-two female subject volunteers participated in the investigation. The subjects were enrolled at Southern West Virginia Community College and were not involved in any type of consistent cardiovascular training. All subjects received medical clearance to participate in the study. Each subject knew prior to volunteering that much time and effort would be required.

The experimental objective of the study was to determine the degree of association between maximal oxygen uptake (VO$_2$ max) values determined by

\textsuperscript{10} Min- Chung Tsai, “A Study to Determine the Relationship between Physical Fitness and Maximal Work Capacity, Professional Activity Skill Level, and Scholastic Aptitudes of Physical Education Majors”, \textit{Dissertation Abstract International 32.11} (June,1972): 6176-A.

\textsuperscript{11} Richard L. Taylor, “The Validity of Predicting the Maximal Oxygen Uptake of Young Females Using Selected Submaximal Estimators”, \textit{Dissertation Abstract International 41.3} (September, 1980): 2342-A.
sophisticated laboratory procedures and predicted values made by use of submaximal step tests and nomograms designed by Astrand and Rhyming and by Margaria and associates. Relationships were also statistically examined between the actually determined maximal oxygen uptake values and running performance on a twelve-minute field tests.

The submaximal step tests for use of nomogram maximal oxygen uptake prediction as well as the run/walk field were done in the gymnasium at Southern Community College. Each subject performed at least two trials for each evaluative measure.

Upon completion of VO$_2$ max estimations and the run/walk field test, the subjects completed their testing requirements at Marshall University, Huntington, West Virginia. The VO$_2$ max was done utilizing a standardized maximal treadmill run while cardiorespiratory variables were monitored and recorded.

The prediction of VO$_2$ max from the Astrand-Rhyming nomogram, the prediction from the Margaria nomogram, and the actual laboratory assessment were all submitted to an analysis of variance to determine if mean differences existed among the three tests. Correlations were also done to establish validity coefficients utilizing actually determined VO$_2$ max as the validity criterion. Test-retest reliability coefficients were computed for the submaximal step tests and the twelve-minute field test.

There were no significant differences in the predictive VO$_2$ max means and the actually determined VO$_2$ max mean, although the means were not significantly different, the validity coefficients of both predictors were very low and the absolute individual prediction error for the Astrand-Rhyming nomogram was 14.6%±13.6% whereas the Margaria predictive error was 17.4% ±11.5%. Trial 1 of the twelve-minute run/walk was significantly associated with the actually determined VO$_2$ max, but below what is generally acceptable (r=0.47, p<0.05) for good test validity. The twelve-minute run/walk was shown to be reliable where r=0.85 and was significant at the 0.1 level.

It was concluded that the nontrained females, 18 to 20 years of age, the Astrand-Rhyming nomogram and the Margaria nomogram were not valid measures of VO$_2$ max when using a step-test workload protocol.
Furthermore, there was a large absolute prediction error introduced by using these protocols. It was also concluded that the twelve-minute run/walk, although appearing to be reliable, may not be a valid indicator of maximal oxygen uptake in untrained females.

Patrick et. al.,\textsuperscript{12} conducted the study with the purpose to identify predictors of the distance achieved during a 6-minute walk test and a Cooper’s 12-minute walk/run test in obese children and adolescents and to evaluate the influence of a residential treatment on the association of these predictors with the distance. A search of the Revalidation Centre Zeepreventorium medical records database of all children and adolescents (age 10 to 18 yrs) treated for obesity between September 2003 and February 2006, revealed 65 charts with all relevant data (anthropometrical, maximal graded exercise, lung function, 6-minute walk test and 12-minute walk/run test) at admission as well as after 3 months treatment. The multidisciplinary treatment has a positive influence on anthropometrical variables, endurance capacity, vital capacity, and residual volume (p<0.05). The distance covered during the 6-minute walk test and the 12-minute walk/run test is correlated with all anthropometrical data and peak VO\textsubscript{2} (p<0.05). After 3 months of treatment, bivariate correlation was stronger for almost every parameter compared to admission. Following a stepwise regression, BMI z-score is a dominant predictor of both field tests at admission and after 3 months treatment. VO\textsubscript{2} peak contributes only significantly in the 12-minute walk/run test at admission.

Conclusion: In obese children and adolescents BMI z-score is the most dominant predictor of the variability in performances on the 6-minute walk test and the 12-minute walk/run test at admission as well as after 3 months of treatment.

Vickers\textsuperscript{13} conducted the study to analyze walk tests as indicators of aerobic capacity. This meta- analysis summarized 39 studies (1,927 participants) relating walk test-performance to laboratory measures of maximal oxygen uptake (VO\textsubscript{2 max}). For adults, the average walk test performance-VO\textsubscript{2} max correlation was r = .56 for a 6-
minute walk, $r = .74$ for a 12-minute walk, $r = .57$ for a 1-kilometer walk, $r = .64$ for a 1-mile walk, and $r = .64$ for a 2-kilometer walk. Each average value was highly significant, so the review was extended to consider multivariate equations combining walk test performance with age, weight, gender, and exercise heart rate to predict VO$_2$ max. These equations have predicted VO$_2$ max accurately and cross-validate well. The standard error of estimate (SEE) for VO$_2$ max predictions from these equations was only 0.32 to 0.40 ml·kg$^{-1}$·min$^{-1}$ larger than that for equivalent statistic for run tests. Walk tests are valid and are comparable to run tests as indicators of VO$_2$ max when the multivariate approach is used.

The direct measurement of true maximal oxygen uptake (VO$_2$ max) and oxygen uptake corresponding to anaerobic threshold (VO$_{2AT}$) is not always practical, especially in middle age and older populations.

Masaki Nakagaichi and Kiyoji Tanaka developed a 12-minute treadmill walk test at a self-selected pace for the evaluation of cardiorespiratory fitness in adult men. The purpose of this study was to develop a simple test that could accurately estimate cardiorespiratory fitness using a sub maximal treadmill walking protocol for middle age, older, sedentary individuals and patients with chronic disease. Subjects for this study were 42 men (44.9 ± 15.7 years), which included 17 patients with coronary heart disease (57.0 ± 9.6 years). VO$_2$ peak and VO$_{2AT}$ were measured using a treadmill protocol (VO$_2$ peak; 38.4 ± 11.6 ml/kg/min, VO$_{2AT}$; 22.9 ± 7.4 ml/kg/min). This simple test assessed the total distance covered in 12 minutes on the treadmill at an intensity corresponding to either (1) 11 on the Borg scale of ratings of perceived exertion (RPE11), (2) 13 on the Borg scale of ratings of perceived exertion (RPE13), or (3) “Optimal” by subjective judgment. The correlation coefficients between VO$_2$ peak or VO$_{2AT}$ and total distance at the three intensities (RPE11; 950 ± 100 m, RPE13; 1080 ± 140 m Optimal; 1050 ± 110 m) were statistically significant, ranging from 0.72 to 0.85. The test-retest reliability coefficient on 12 subjects was 0.98. The oxygen uptake (VO$_2$) was measured during the three walk tests on 15 subjects. There were no significant changes in submaximal VO$_2$ values from min 4 to min 12

---

(RPE11; 19.8 ± 4.7 ml/kg/min, RPE13; 24.1 ± 4.9 ml/kg/min, Optimal; 23.1 ± 4.8 ml/kg/min) in any of the three tests. Similarly, the three submaximal VO\(_2\) values did not differ from the VO\(_{2AT}\) value (21.2 ± 8.3 ml/kg/min) obtained in the initial maximal test. These results suggest that the 12-min submaximal treadmill walk test (STWT) is a valid method for the assessment of VO\(_2\) peak and VO\(_{2AT}\). Therefore, the STWT could be a useful performance test for evaluating cardiorespiratory fitness in middle age, older, sedentary individuals and patients with chronic disease.

### 2.2 Validation of Different Run/Walk Tests For Different Populations

Jose et. al.,\(^{15}\) reviewed the criterion-related validity of field-based fitness tests in youth. The objective of this systematic review was to comprehensively study the criterion-related validity of the existing field-based fitness tests used in children and adolescents. The studies were scored according to the number of subjects, description of the study population and statistical analysis. Each study was classified as high, low and very low quality. Three levels of evidence were constructed: Strong evidence, when consistent findings were observed in ≥3 high-quality studies; moderate evidence, when consistent findings were observed in 2 high-quality studies; and limited evidence when consistency of findings and/or the number of studies did not achieve the criteria for moderate. The results of 73 studies (50 of high-quality) addressing the criterion-related validity of field-based fitness tests in children and adolescents indicate that: There is strong evidence indicating that the 20m shuttle run test is a valid test to estimate cardiorespiratory fitness; handgrip strength test is a valid measure of musculoskeletal fitness; skinfold thickness and body mass index are good estimates of body composition, and waist circumference is a valid measure to estimate central body fat. They found moderate evidence that the 1-mile run/walk test is a valid test to estimate cardiorespiratory fitness. A large number of other field-based fitness tests presented limited evidence, mainly due to a limited number of studies (1 for each test). The results of the present systematic review should be interpreted with caution due to the substantial lack of consistency in reporting and designing the existing validity studies.

\(^{15}\) [http://bjms.bmj.com/cgi/content/absrract/bjsm.2009.05832/v/](http://bjms.bmj.com/cgi/content/absrract/bjsm.2009.05832/v/)
According to Ross and Vickers\(^\text{16}\) previous summaries of the research evidence have shown that run tests are valid indicators of VO\(_2\) max, but analysis also indicated that validity differed from one test situation to another. Their study utilized data from 166 samples to test the general hypothesis that differences in testing methods and could account for the cross-situational variation in validity. Only runs less than 2 km or less than 12 min were included. This criteria restricted attention to tests with maximal validity. The estimated average validity was \(r = 0.75\). Validity was higher for fixed-time runs than for fixed-distance runs and in samples with greater variability in VO\(_2\) max. This difference must be interpreted cautiously because studies that directly compared these two types of run test have found little or no difference. Validity was not related to the age, gender, fitness, or running experience of the population tested or to the method used to measure VO\(_2\) max. A random-effects model estimated the 95% credibility interval for the validity of run tests at \(r = 0.52\) to \(r = 0.84\). The evidence was consistent with the view that some methods factors affect run test validity, but tests are equally valid for different types of people. This summary provided a point of departure for the design and interpretation of future run test validation studies.

The study by Diaz et. al., \(^\text{17}\) was designed to determine the validity and reliability of the 1,000 meters walk-run test in adults. Fifty-one healthy subjects (31 men and 20 women) participated in four maximal tests; two in a laboratory on a treadmill for direct measurement of VO\(_2\) max (L1 and L2) and twice in a track for distance walk-run time in 1,000 meters (C1 and C2). Values were analyzed by interclass correlation, Pearson product moment and "t" test.

**Results:** The VO\(_2\) max in L1 by L2 were 2.67 and 2.70 L.min\(^{-1}\), \((R = 0.97)\) and meanwhile VO\(_2\) max estimated from field were 44.2 and 46.2 mL.kg\(^{-1}\).min\(^{-1}\), \((R = 0.98)\). Pearson correlation obtained from all subjects between laboratory and field test was of \(r = 0.88\), without significant difference \((P > 0.05)\). From those data they developed the following equation: \(\text{VO}_2\max = 71.66 - 5.85 (t)\), where 71.66 and 5.85 are constants and \(t\) is the time employed in performing the test, \(R = -0.86\), \((p < 0.05)\).

\(^{16}\) [http://www.stormingmedia.us/44/4421/A442124.html](http://www.stormingmedia.us/44/4421/A442124.html)

\(^{17}\) Diaz et. al., “Validity and Reliability of the 1,000 Meter Aerobic Test”, Rev Invest Clin. 52.1 (Jan-Feb 2000) :44-51.
**Conclusion:** The 1,000 meters distance walk-run time is highly reliable and valid test for estimation of VO\textsubscript{2} max in Mexican people. The test is safe, easy and short and can be administrated with a minimal amount of equipment.

Buono\textsuperscript{18} studied the Validity and reliability of a timed 5 km cycle ergometer ride to predict maximum oxygen uptake. The purpose of this study was to determine the validity and reliability of a timed 5 kilometer cycle ergometer ride to predict maximum oxygen uptake (VO\textsubscript{2}). Fifty-two healthy volunteers had their (VO\textsubscript{2}) determined during a maximal treadmill run. They also performed a timed 5 kilometer cycle ergometer ride. The resistance setting for the cycle ride was set at a rate of 0.5 kg/20 kg body weight. A significant inverse relationship was found between the logarithm of cycle time and (VO\textsubscript{2}) \((r = -0.83)\). Furthermore, the test- retest reliability for the 5 kilometer ride was determined to be \(r = 0.93\) \((n = 20)\). These results suggest that a timed 5 kilometer cycle ergometer ride is a valid and reliable predictor of (VO\textsubscript{2}). Furthermore, the timed cycle ride offers several methodological advantages which make it potentially useful in clinical, military, and research settings.

Laukkanen, Oja, Pasanen and Vuori \textsuperscript{19} examined the criterion validity of a two-kilometer walking test for predicting the maximal oxygen uptake of moderately to highly active middle-aged adults. This work examined whether prediction models based on a 2-km walking test are valid for predicting the VO\textsubscript{2} max of middle-aged, healthy, moderately to highly physically active adults. Sixty-seven, 35-45 years old moderately active men and women and 35-55 years old healthy men who participated regularly in marathon-long sports competitions were studied. VO\textsubscript{2} max was determined in an uphill walk-run on a treadmill. The 2-km walking test was conducted on a flat outdoor course. The subjects walked the distance as fast as they could. Walking time, heart rate at the end of the walk, age and body mass index were entered in the prediction formulas as established in the original study. The total errors of prediction and the correlation coefficients between the measured and predicted


VO₂ max (ml kg⁻¹ min⁻¹) for the moderately active women and men and for the competitors were 5.2, 5.7 and 7.7 ml kg⁻¹ min⁻¹ and 0.55, 0.79 and 0.60, respectively. The measured relative VO₂ max was slightly under predicted in all groups. The results suggest that the 2-km walk test is a reasonably valid test of maximal aerobic power for moderately fit men and women, but less valid for very fit individuals.

Lai²⁰ conducted a study with the objective to validate criterion-referenced standards for the mile run test and the multi stage fitness test using the criterion groups validation model. Cross-validation was then performed on independent sample of subjects in order to substantiate the findings of the validation process. In the final analysis both the validation and cross validation samples were collapsed for a total combined sample to determine more stable estimates of the criterion referenced cutting score.

The selection of the optimal criterion standards was based upon findings. Cutting more that not only minimized the probability of Type-I error and losses associated with the misclassification of false nonmasters but also maximized the probability of making correct decisions established upon training and participation in physical activity. The final resulting optimal cutting scores obtained included 11:00 minutes for the boys mile run, 12:30 minutes for the girls mile run, 26 laps for the boys multistage fitness test, and 22 laps for the girls multistage fitness.

Fernhall et.al, ²¹ investigated the validity and reliability of the half-mile run-walk as an indicator of aerobic fitness in children with mental retardation.

The purpose of this study was to determine the relationship between VO₂ max and the 1/2-mile run-walk and the reliability of each in children with mental retardation (MR). Twenty-three children (13 boys, 10 girls) with mild or moderate MR participated in the study. Two maximal treadmill protocols with metabolic measurements and two 1/2-mile run-walk trials were randomly conducted on separate days. There was no difference between Trial 1 and Trial 2 for VO₂ max (28.2 versus

29.6 ml·kg⁻¹·min⁻¹), maximal heart rate (175 versus 177 bpm), or run-walk time (7.2 versus 7.1 min⁻¹). The test-retest correlations were r = .90 for VO₂ max r = .81 for maximal heart rate, and r = .96 for the 1/2-mile run-walk (p < .05). The correlation between VO₂ max and the 1/2-mile run-walk was r = -.60 (p < .05). Adding body mass index to the model improved R to .67 (SEE = 7.3). The 1/2-mile run-walk was a reliable test, but had questionable validity as an indicator of aerobic capacity in children with mild and moderate MR.

Castro et. al.²² assessed the criterion related validity of 1/2 mile run/walk (1/2MRW) test for estimating VO₂ peak in children aged 6-17 years. The criterion related validity of the Fernhall's equation in a sub-group of children aged 10-17 years was also examined. A total of 86 children completed a maximal graded treadmill test and the 1/2MRW test. The cohort was randomly divided into either validation (n=47) or a cross-validation (n=39) group. A regression equation was computed and assessed through several error measures, and the Bland and Altman method. There was no systematic bias in the validation group or in the cross-validation group (P > 0.1). The root mean sum of squared errors (RMSE), and the percentage error were 6.5 ml/kg/min, and 13.9%, respectively. These figures were very similar in the cross-validation group. The new equation had a lower RMSE and percentage error than the Fernhall's Equation (6.2 versus 19.7 ml/kg/min, and 16% versus 50.4%, respectively, P<0.001). The Fernhall's equation showed a significant underestimation of VO₂ peak (18.1 ml/kg/min, P<0.001). In conclusion, the new regression equation was valid for estimating VO₂ peak from the 1/2MRW time, sex, and body mass index in healthy children aged 6-17 years, and was more accurate than Fernhall's equation in the sample studied.

Jose et.al.,²³ assessed the criterion-related validity of Cureton's equation for estimating peak oxygen consumption (VO₂ peak) from the one-mile run/walk test in endurance-trained children aged 8-17 years. Altogether, 66 physically active white

---


children and adolescents (32 girls, 34 boys) completed a graded exercise test to volitional exhaustion and the one-mile run/walk test. Cureton's equation was used to estimate VO$_2$ peak, and was assessed using several error measures. Agreement between measured VO$_2$ peak and estimated VO$_2$ peak was analyzed by the Bland and Altman method. The correlation coefficient between measured VO$_2$ peak and one-mile run/walk time was 0.59 ($P < 0.001$) and that between measured and estimated VO$_2$ peak was 0.70 ($P < 0.001$). The mean difference between measured and estimated VO$_2$ peak was 10 ml·kg$^{-1}$·min$^{-1}$ (95% CI = 9.2-11.8; $P < 0.001$). The standard error of the estimate was 3 ml·kg$^{-1}$·min$^{-1}$, and the percentage error was 32%. There was a positive association between the measured and estimated VO$_2$ peak difference and the measured and estimated VO$_2$ peak mean, which indicates that the higher the VO$_2$ peak the higher the error of the estimate. These findings did not change markedly when the analyses were performed by sex, age group or body mass status. These results suggest that Cureton's equation systematically underestimates VO$_2$ peak in endurance-trained children with high VO$_2$ peak.

Mechelen, Hlobil, and Kemper$^{24}$ validated two running tests as estimates of maximal aerobic power in children. In order to validate the maximal multistage 20 meter shuttle run test (MST) by Leger and Lambert as an estimate of maximal aerobic power (VO$_2$ max) and to compare the results of this test with the results of a 6 minute endurance run, 82 subjects (41 boys and 41 girls) aged 12-14 performed the 20-MST and the 6 minute endurance run, and had their VO$_2$ max directly measured during maximal treadmill running. The 20-MST is a maximal running test starting at a running speed of 8.0 km h$^{-1}$, which is increased every minute and in which the pace is set by an audio signal. Performing the test, one runs a 20-meter course back and forth. The test result was expressed as "palier" (one palier is approximately one minute). The mean results of the 20-MST were, for boys, 8.0 palier (±1.7) and for girls, 6.4 palier (± 1.5). The mean results of the 6 minute endurance run were for boys, 1264.4 meters (± 160.8), and for girls, 1103.9 meters (± 144.7). The mean VO$_2$ max for boys was 53.2 ml. kg.$^{-1}$ min.$^{-1}$ (± 5.4) and for girls, 44.1 (± 4.8) ml. kg.$^{-1}$ min.$^{-1}$. The

---

correlation coefficient between VO\(_2\) max and the 20-MST was found to be 0.68 (± 3.9) for boys, 0.69 (± 3.4) for girls and 0.76 (± 4.4) for both sexes, and that of VO\(_2\) max with the 6 min endurance run was 0.51 (± 4.6) for boys, 0.45 (± 4.3) for girls and 0.63 (± 5.3) for both sexes. The conclusion was that the 20-MST is a suitable tool for the evaluation of maximal aerobic power. Although the differences in validity between the 20-MST and the 6 minutes endurance run were statistically not significant (p > 0.05), for reasons of practicability the 20-MST should be preferred to the 6 minutes endurance run when used in physical education classes.

Balke\(^{25}\) developed a simple test for examining functional capacity: measuring the distance walked during a defined period of time. A 12-min performance test was then developed to evaluate the physical fitness of healthy individuals.\(^{26}\) This test was subsequently modified for use in patients with chronic bronchitis.\(^{27}\) In order to allow the test to be used in patients with respiratory diseases, for whom walking 12 min was too demanding, a shortened version, the 6-min walk, was developed, and found to perform equally as well.\(^{28}\) The review of functional walking tests concluded that the 6-min walk test (6MWT) is easier to carry out, more acceptable and provides a better reflection of activities of daily living than other walk tests.

Li et. al.,\(^{29}\) assessed the reliability and validity of the six minute walk test (6MWT) in healthy children. Chinese secondary school students were randomly recruited. They visited the unit on two occasions, separated by 2 weeks. Physical examination and standardized maximum incremental exercise testing on a treadmill were performed on the first visit. Spirometry and 6MWT were carried out on the second visit. A randomly selected subgroup was invited to return for repeat 6MWT at an interval of 2–4 weeks.


Seventy-eight subjects were recruited; however, four failed to achieve maximal effort on exercise test. The final group included 43 young females and the mean ±SD age of the subjects was 14.2±1.2 years. Physical examination was unremarkable in all cases. The mean ±SD percent predicted forced expiratory volume in one second was 91.4±10.2%. Concurrent validity was demonstrated by good correlation between the six minute walking distance and maximum oxygen uptake determined on the exercise treadmill. Test–retest reliability was undertaken in 52 subjects, and the intraclass correlation coefficient (95% confidence interval) was calculated as 0.94 (0.89–0.96). In addition, Bland and Altman plots demonstrated a high degree of repeatability.

In healthy children, the six minute walk test is a reliable and valid functional test for assessing exercise tolerance and endurance.

2.3 Reviews on One Mile Jog Test

George et. al.,30 conducted the study with the purpose to develop a submaximal field test for the estimation of maximal oxygen uptake (VO₂ max) using a one-mile track jog. Second purpose was to determine the accuracy of the 1.5-mile run in estimating VO₂ max for both male and female subjects. VO₂ max was measured in 149 relatively fit college students (males = 88, females = 61) 18-29 years using a treadmill protocol (mean ± SD; VO₂ max = 47.7 ± 6.3 ml.kg⁻¹ . Mile⁻¹). Multiple regression analysis (N= 54) to estimate VO₂ max from the submaximal, steady-state one-mile track jog yielded the following validation (V) model (radj = 0.87, SEE = 3.0 ml.kg⁻¹ .min⁻¹): VO₂ max = 100.5 + 8.344 * Gender (0 = female; 1 = male) - 0.1636 * Body Mass (kg) - 1.438 * Jog Time (min-mile⁻¹) - 0.1928 * Heart Rate (bpm). To help ensure that a submaximal level of exertion was realized for the one-mile track jog, elapsed jog time was restricted to >=8.0 minute for males and >=9.0 minute for females and exercise HR to <=180 bpm. Cross-validation (CV) of the 1-mile track jog comparing observed and estimated VO₂ max (N = 52) resulted in radj = 0.84, SEE = 3.1 ml.kg⁻¹ .min⁻¹. Multiple regression analysis (N = 50) to estimate VO₂ max from the 1.5-mile run (N = 49, radj = 0.90, SEE = 2.8 ml- ml.kg⁻¹.

min⁻¹; CV: N = 47, radj = 0.82, SEE = 3.9 ml·kg⁻¹·min⁻¹), used elapsed run time, body mass, and gender as independent variables. The results indicate that a submaximal one-mile track jog can accurately predict VO₂ max and is a viable alternative to maximal performance tests such as the 1.5-mile run.

The study by Zwiren and others 31 was performed to compare the acceptability of five tests including a 1.5 mile run, a mile walk, a step test and two tests that use heart rate responses while the subject is exercising on a bicycle ergometer. Thirty eight female volunteers aged 30-39 years had VO₂ max measured on the cycle ergometer and on the treadmill, analysis of variance (ANOVA) and Pearson’s product moment correlation were applied as statistics. The results suggest both the walk and run tests are satisfactory predictors of VO₂ max in 30-39 years old females.

Karen, Kate and Vincent 32 compared the field methods to assess Cardiorespiratory fitness among neophyte exercisers. In this study, a single-factor within-subjects (repeated measures) factorial design was used to compare three field measures of Cardiorespiratory fitness among sedentary women: (a) the Queen’s college step test (QCST), (b) the Rockport 1-mile walk (RW), and (c) a non exercise estimation of VO₂ max (NE). The sample consisted of 31 racially and ethnically diverse female college students (mean age= 24.8 years). No significant differences within-subjects were found in the three measures of VO₂ max (F = 1.89, p = .17) among Black, Hispanic, White non-Hispanic, or Asian women, but relative perceived exertion scores were significantly higher for the QCST than for the RW (t = 9.79, p < .001) for all groups. The mean calculated VO₂ max for the QCST was 35.90 ml/kg/min for the subset of women ages 18 to 25 and 31.85 for those ages 26 to 46. These values represent a "poor" to "below average" score for aerobic capacity among women in both age groups. Data from this preliminary study suggest that both the run and walk test and the NE test are comparable to the QCST as valid and reliable field

measures of aerobic fitness and appear to be good alternatives to step testing among sedentary individuals.

Widrick et. al., 33 conducted the study with the purpose to determine whether a test developed to predict maximal oxygen consumption (VO$_2$ max) during over-ground walking, was similarly valid as a predictor of peak oxygen consumption (VO$_2$) when administered during a 1-mile (1.61 km) treadmill walk. Treadmill walk time, mean heart rate over the last 2 full minute of the walk test, age, and body mass were entered into both generalized (GEN Eq.) and gender-specific (GSP Eq.) prediction equations. Overall results indicated a highly significant linear relationship between observed VO$_2$ peak and GEN Eq. predicted values ($r=0.91$), a total error (TE) of 5.26 ml·kg$^{-1}$·min$^{-1}$ and no significant difference between observed and predicted VO$_2$ peak mean values. The VO$_2$ peak for women ($n=75$) was predicted accurately by GSP Eq. ($r = 0.85$; TE = 4.5 ml·kg$^{-1}$·min$^{-1}$), but was slightly over predicted by GEN Eq. (overall mean difference = 1.4 ml·kg$^{-1}$·min$^{-1}$; $r=0.86$; TE = 4.56 ml·kg$^{-1}$·min$^{-1}$). No significant differences between observed VO$_2$ peak and either GEN Eq. ($r=0.85$; TE=4.3 ml·kg$^{-1}$·min$^{-1}$) or GSP Eq. ($r=0.85$; TE = 4.8 ml·kg$^{-1}$·min$^{-1}$) predicted values were noted for men ($n=48$) with VO$_2$ peak values less than or equal to 55 ml·kg$^{-1}$·min$^{-1}$. However, both equations significantly under predicted VO$_2$ peak for the remaining high VO$_2$ peak men ($n=22$). In conclusion, the over-ground walking test, when administered on a treadmill, is a valid method of predicting VO$_2$ peak but under predicts VO$_2$ peak of subjects with observed high VO$_2$ peak values.

2.4 Effects of Run and Walk Exercise Programmes

Serfass 34 conducted the study to determine changes in cardiorespiratory fitness and body composition of participants in selected physical education classes. The objectives of this study were to: (1) test for improvement in VO$_2$ max in male college students participating in eight weeks of soccer (N=17), conditioning (N=18),

and swimming (N=17); (2) test for improvement in running performance of the 50 yards dash, 200 yard run-walk and 12 minute run and walk test; (3) determine the extent of changes in body composition variables during the eight week physical education programs; (4) make comparisons between group pre and posttest measures of cardiorespiratory fitness and body compositions; (5) show relationships between physical fitness and body compositions variables; and (6) develop regression equations to predict VO$_2$ max from more conveniently measured independent variables. VO$_2$ max improved significantly in all three activity groups. The soccer group demonstrated a small but statistically significant increase in body fat (decrease in total body water). Regression equations, developed to predict VO$_2$ max, produced $R^2$ ranging from 0.10 to 0.64. The best subset variables for the prediction of VO$_2$ max was a pre-test subset containing body weight, 600 yard run-walk, and 12 minute run and walk test ($R^2= 0.635$, standard error of estimate 3.615 cc/kg BW/min.).

Renfrow\textsuperscript{35} studied the effects of a twelve minute aerobic training program on second and fourth grade students. Two hundred thirty-two (232) second and fourth graders participated in the study. The number comprised all the second and fourth graders at three randomly selected elementary schools in Fayetteville. The students were measured on the following variables: height, weight, four site (triceps, subscapula, iliac crest and biceps) skinfold reading, fifty yard dash, vertical jump, shuttle run, flexibility and nine- minute run.

The students were then divided into treatment and control groups. The groups were selected by classes for administrative ease in program participation. After a twenty-one week aerobic program, consisting of twelve minutes of aerobic activity per day, the groups were retested on the same variables as in the original test. Fourth graders were also tested on the SRA, a standardized academic achievement test. Comparisons were made between the treatment and control groups in percentage body fat (F Ratio of 16.180 at 0.1), triceps sub scapula sum (F Ratio of 10.497 at 0.01) and weight (F-Ratio of 144.681 at 0.01).

\textsuperscript{35} Nolen Edward Renfrow, “The Effect of a Twelve Minute Aerobic Training Program on Second and Fourth Grade Students”, Dissertation Abstract International 42.6 (December,1981): 2562-2563 A.
Results of the study indicated that treatment total groups improved in percentage body fat (F Ratio of 16.180 at 0.01 level) and weight (F Ratio of 144.681 at 0.01 level).

The second grade treatment group did not have any significant improvements on the analysis of covariance. The fourth grade treatment groups significantly improved in percentage body fat (F Ratio of 12.901 at 0.01 level), triceps sub scapula sum (F Ratio of 5.954 at 0.01 level), weight (F Ratio of 11.307 at 0.01 level), vertical jump (F Ratio of 4.237 at 0.01 level) and flexibility (F Ratio of 4.945 at 0.01 level).

According to the results of the study, the conclusion was that an aerobic training program has little or no effect on cardiovascular endurance in elementary school children. However, the aerobic program does not have a significant effect on percentage of body fat.

Davey 36 conducted a study with the purpose to examine the effects of an eight week structured walking/jogging program on the cardiovascular fitness, self-concept, and body image of mildly retarded adults. The parameters of daily attendance, diet and behavior were observed for descriptive purposes.

The subjects were thirty-three mildly mentally retarded adults (twenty-two male and eleven females) employed by the Howard Training Centre, a nonresidential sheltered workshop located in Modesto, California. Subject’s ages were twenty-one to forty-six years. Subjects Intelligence Quotient ranged from 52 to 69.

Cardiovascular fitness was measured by the Cooper’s 12 minute run and walk test and a PWC 170 bicycle ergometer test. The cardiovascular fitness variables evaluated were resting heart rate, resting blood pressure, predicted workload, and predicted VO₂ max.

Self-concept was measured by the Piers- Harris Children’s Self-Concept Scale. Body image was measured by the Physical Appearance and Attributes subscale of the Piers- Harris.

Subjects were randomly assigned to either an experimental group or control group. The experimental group participated in an eight week structured walking/jogging program.

---

jogging program five days per week, fifteen minutes per day. The control group continued in their normal daily work activities.

Significance (p<0.05) was found for the experimental group cardiovascular fitness variables of the Cooper test predicted VO$_2$ max, resting heart rate, resting blood pressure and self-concept. Significance (p<0.05) was found for experimental group body image.

The results of this indicate that an eight week structured walk-jogging program has a positive effect on the cardiovascular fitness variables of Cooper test predicted VO$_2$ max, PWC 170 predicted workload and body image of mildly mentally retarded adults.

2.5 Relationship among Cardiorespiratory Fitness, Physiological Parameters and Run and Walk Tests

Cureton $^{37}$ determined running and walking endurance performance in children. The purpose of the study was to investigate the relative importance of body structure, cardiovascular-respiratory capacity and basic motor abilities in accounting for variation on tests of running and walking endurance performance in 80 children, 7 to 12 years of age, to determine if these tests could be interpreted as measures of cardiovascular-respiratory capacity. A multivariate, multistage path model was developed in which height, percent total body fat, static leg strength, VO$_2$ max (ml/min.kg) and 50-yard dash time were postulated as determinates of each of four endurance tests namely, the 600 yard run, the mile run, a constant pace, all-out treadmill run and a progressive, grade- incremented, all-out treadmill walk. The total legitimate association of an independent variable with an endurance performance test, computed by summing its direct and nonspurious, nonconfounded indirect effects, was used to indicate its importance as endurance performance determine. Body fat, height, VO$_2$ max (ml/min.kg) and the 50 yard dash time were each found to have significant legitimate associations with each endurance performance test. Body fat and 50-yard dash time were the most important determinants of the 600-yard run and

mile run; VO$_2$ max (ml/min.kg) and body fat were the primary determinants, similar in importance, of the treadmill run and treadmill walk.

It was concluded that determinants of running and walking endurance performance in elementary-school-age children are multivariate in nature and cannot be interpreted as only, or even predominantly, a reflection of cardiovascular-respiratory capacity.

Fothergill $^{38}$ conducted a study to find out the relationship between cardiovascular fitness and the number of heart beats accumulated by college men during work of selected intensity. It was designed to determine (1) the relationship that exists between an individual’s fitness level and the number of heart beats occurring during periods of exercise at selected working speeds and (2) the influence of exercise duration on strengths of the relationships.

**Procedure:** Sixty male students, at East Texas State University volunteered to be tested. The first test administered was the modified Balke treadmill test. Subjects were then administered a series of exercise bouts (1) a four minute stationary standing exercise, (2) a three mile-per-hour treadmill walk of fourteen minutes, (3) a four mile-per hour treadmill walk of eleven minutes, (4) a five mile-per hour treadmill walk of nine minutes (5) a six mile-per hour treadmill walk of seven minutes and (6) a seven mile-per hour treadmill walk of six minutes.

Pearson product-moment correlations were computed for modified Balke treadmill test scores and the heart beat accumulation scores of the total sample and each of the three fitness groups. The 0.05 level of significance was used to test eight null hypotheses.

**Findings:** Results of the study indicated the following fitness level and accumulative heart rate comparisons: (1) the relationship between fitness and the number of heart beats accumulated by the total sample was high and very dependable following three or four minutes of exercise at the jogging speeds, (2) the relationship of fitness scores to the number of heart beats accumulated by high fit subjects was high and very dependable after two to four minutes of continuous exercise at jogging

---

speeds (3) the relationship between fitness and heart beats accumulated by middle-fit subjects showed consistent and moderate strengths only after two minutes of continuous jogging at a fast jogging speed (4) the relationship between fitness and heart beats accumulated by low-fit subjects was very high and dependable after four minutes of a slow-jog exercise. However, five of the low-fit subjects were unable to exercise at jogging speeds with submaximal effort, indicating that more intense speeds were too severe for safe testing.

Conclusions: Based upon the findings of this study, the following conclusions were drawn: 1. There is a significant relationship between fitness and the heart beats accumulated by college men. 2. Though fitness levels and heart beats accumulations are significantly related through broad ranges of work intensity, the relationship is not great enough to accept accumulated heart beats as a practical indicator of cardiovascular fitness. 3. Sufficiently high relationships between fitness and heart beat accumulations appear only after two to four minutes of continuous exercise at jogging speeds. 4. Low-fit subjects cannot maintain a submaximal level of effort while performing at work intensities severe enough to produce very dependable relationships between fitness and accumulated heart beat scores. 5. The use of accumulated heart beat scores by coaches and teachers to measure fitness levels has limited application.

Takacs 39 conducted the study to find out the heart rate response of children to four separate bouts of running. The purpose of this investigation was to determine the heart rate response of children of varying ages to four runs of varying lengths. More specifically, it was the purpose of this study to determine: (1) the peak heart rate response of children aged 6 to 12 to four separate running bouts of 200, 400, 600, and 800 yards. (2) The heart rate responses of children during initial, intermediate, and final stages in running performances of each of the four distances. (3) The heart rate recovery of children during each 30-second segment within a 5-minute recovery period following the termination of each of the four runs. (4) The extent to which heart rate for the four running bouts meets or exceeds a threshold of training value.

39 Robert Frank Takacs, “Heart Rate Response of Children to Four Separate Bouts of Running”, Dissertation Abstract International 32.11 (June, 1972): 6801-A
Procedure: Ninety-six boys from the College Station, Texas area, grades one through six inclusive, served as subjects for this investigation. Four runs of 200, 400, 600, and 800 yards were administered. Each boy ran a different distance for four consecutive days. Each of the 16 subjects at each of the six grades levels was administered each of the running distances while being monitored for heart rates, using a biotelemetry radio network.

Heart rates were monitored during each 30-seconds segment throughout the running distances, and for a 5-minute recovery period following the termination of each of the four runs.

Results: Results were analyzed by means of analysis of variance for a 4x6 by levels factorial design. In terms of cardiac cost, the 800-yards run were significantly higher than any of the other runs, while the 200-yards run significantly lower. There was no significant difference between peak heart rate responses for the 400 and 600-yard runs.

Conclusions: Based on the results obtained in the study, the following conclusions were offered: (1) heart rate responses to running are not proportional to the distance run. However, heart rate responses for all children are greatest in the longer runs and lesser in the shorter runs; (2) response to running is near maximal after 30 seconds of running, regardless of the distance covered; (3) runs in excess of 200 yards produce near maximal heart rates, regardless of age and running distance; (4) heart rate response to running is not directly related to age, however, age could be used as a means for general classification in determining heart rate responses to running; (5) all children, regardless of their physical fitness level, produce maximal efforts in runs of all lengths as determined by their heart rate responses; (6) recovery after running is nearly complete after 1 minute and 30 seconds of recovery; (7) younger children tend to have a slower recovery to running, especially in longer distance runs; and (8) heart rates tend to be lower after 4 minutes of recovery than they are prior to the administration of tests where equipment is being used.
Foster conducted a study to find out the relationship of selected physiological training, and performance measures to distance running performance.

In order to enlarge the range and enhance the scope of descriptive data concerning the relationship of physiological functions to distance running performance, selected physiological, training and performance measures were determined for 24 well-trained competitive runners. VO\textsubscript{2} max during submaximal and maximal treadmill running, muscle fiber composition and muscle enzyme activities were determined using commonly employed laboratory techniques. The volume and intensity of training were determined from analysis of training diaries and sprinting speed was determined from a 220 yard time trial. Distance running performance was determined from participation in a series of races ranging from 1-10 miles. Both correlation statistics and analysis of variance indicated that VO\textsubscript{2} max, muscle fiber composition, volume of training and sprint speed were significantly related to distance running performance. Muscle enzyme activity was not related to performance. It was concluded that cross-sectional variations in distance running performance were primarily attributable to differences in VO\textsubscript{2} max and that other factors including muscle fiber composition, training volume and sprint speed might act to attenuate the VO\textsubscript{2} max-performance relationship. The findings that muscle enzyme activity was not related to cross sectional differences in performance was taken as evidence of the need for longitudinal studies of running performance.

Dunn’s problem of the study was to examine the relationship between fifth and sixth grade children’s maximal oxygen intake and running performance at distances of 600, 900, 1200 and 1600 yards. Additional sub-problems were: to establish a reliability coefficient for the distance run mostly related to maximal oxygen intake, and to determine whether there are differences in sex, grade and sex within grade.

---


The findings were based on the maximal oxygen intake and running performance of 110 children. The data was analyzed by a multiple regression program, test-retest reliability coefficient and analysis of variance.

The following conclusions were made: (a) The four running performance tests are equally, but not highly related to maximal oxygen intake: however, they are at present the best single measure of the cardiovascular fitness of fifth and sixth grade children available. (b) The 1600 yard run-walk is a reliable test. (c) The boys running times and maximal oxygen intake values were better than the girls: however, no real differences were found between grades.

Frank Irwin conducted a study to determine optimal duration of a heavy work endurance test in relation to oxygen intake capacity. The major emphasis of this study was to determine experimentally the relative importance of individual differences in a criterion physiological process (namely the maximal oxygen intake) in accounting for individual differences in an independent test of heavy work capacity (performed on a bicycle ergometer). The theoretical expectation was that individuals with a high maximal oxygen intake would have a large amount of heavy work endurance. A second aspect was to determine the optimal duration of the endurance performance test, using VO\textsubscript{2} max as the criterion of validity.

VO\textsubscript{2} max was measured in 50 male college students using the step-increment method. The initial resistance was 2.5 kp at 60 rpm, and was increased by 0.5 kp each two minutes until the subjects would no longer turn the ergometer, or until the rate fell to 40 to 50 rev/min. In contrast, the endurance performance test was of the “steady pace” type, in which at work rate of 1656 kp-m/min. for 12 minute. The rate of pedaling (and thus the work rate) declined as fatigue developed, while the friction load remained constant at 24 kp throughout the test. There were 12 performance scores for each individual, consisting of the cumulated work output for minute was the area underneath the drop-off curve cumulated up to a particular minute.

The validity coefficients (i.e., the minute-by-minute correlations between the criterion (VO\textsubscript{2} max) and the endurance performance scores) progressively from non-

\begin{flushright} Frank Irwin, “Optimal Duration of a Heavy Work Endurance Test in Relation to Oxygen Intake Capacity”, Dissertation Abstract International 30.8 (February, 1970): 5181-A \end{flushright}
significance at minutes 1 and 2 to r-0.40 at minute 3, 0.71 at minute 6, and 0.78 at minute 12. An empirical equation of the form \( Y = C - at^k \) was used to fit a smooth curve to be trend of the correlations so that the changing curvature could be estimated quantitatively. The amount of change in correlation was small in the later stages of performance, especially so after minute 8 where the change was less than 0.4 correlation units between minutes 8 and 12.

The correlation between body weight and the 12 minute performance was non-significant (r=0.19); and minute-by-minute performance scores was also non-significant. The correlation between body weight and VO\(_2\) max was also non-significant (r=0.23).

On the basis of the above experimental results, it was concluded that individual differences in endurance capacity are only moderately related to individual differences in endurance in VO\(_2\) max, the common variance being 61 percent. VO\(_2\) max does not effectively predict endurance performance unless the performance is continued for at least 7 or 8 minutes under the conditions of the present experiment. With a 12 minute test the validity is 96 percent of the asymptotic value, suggesting little further gain can be expected beyond 12 minutes. Body weight is substantially independent and uncorrelated with heavy work endurance or with VO\(_2\) max.

Mota et.al,\(^{43}\) conducted the study with the purpose to examine differences of cardiorespiratory fitness (CRF) among weight groups, and the associations of CRF with obesity (body mass index) in a sample of young children. Anthropometric data (height, body mass, and two skinfolds) were collected for 255 healthy children aged 8-10 years (127 boys and 128 girls). Children were placed in three groups (nonobese, overweight, and obese), using body mass index (BMI), sex and age-specific cutoff points. Cardiorespiratory fitness was assessed with a one-mile run test. Participants were separated into two groups: fit and unfit, according to age and sex-specific scores defined by Fitnessogram. The prevalence of overweight (30.5% versus 29.1%) and obesity (13.2% versus 12.6%) was at the same magnitude for boys and girls. Overall, 109 children (42.7%) were overweight and obese. Sums of skinfolds, weight, and BMI were significantly lower \((P < 0.05)\) in lean boys and girls compared to their

Chapter-2  
Review of the Related Literature

overweight and obese counterparts. Regarding height, no significant differences were found in girls, while in boys, significant differences were found only between nonobese and obese. No differences were found in obesity groups according to cardiorespiratory fitness in boys, while significant differences were found for girls ($P < 0.01$). Logistic regression analysis showed that girls who were overweight (odds ratio = 0.05, $P = 0.000$) or obese (odds ratio = 0.09, $P = 0.001$) were likely to be unfit. No significant results were found in boys. Overweight and obese children presented higher sums of skinfolds and weight compared with their lean counterparts. Increased BMI was significantly associated with lower CRF in girls. Thus, data clearly showed potential gender differences of body composition in CRF, which would be of great clinical significance. Therefore, even at young ages, at least for girls, the beneficial impact of low BMI values on CRF is shown with important clinical and public health implications.

2.6 Different Physiological Variables as Independent Variables and VO$_2$ Max as Dependent Variable

The study by Rivera et. al.,$^{44}$ examined the hemodynamic factors associated with the lower maximal O$_2$ consumption (VO$_2$ max) in older formerly elite distance runners. Eleven young male competitive runners were selected as subjects. Each runner performed exercise tests on the separate days, at least 48 hours apart, within a two week period. Heart rate and VO$_2$ max were measured during submaximal and maximal treadmill exercise and cardiac output was determined using acetylene at 30, 50, 70 and 85% VO$_2$ max. Weight, height and skinfold at seven sites (triceps, subscapular, suprailliac, abdomen, thigh, chest, maxilla), a mercury sphygmomanometer and a motor driven treadmill were the equipments used for the study. One tail analysis of variance and other descriptive statistics conclude that VO$_2$ max is lower in master runners because of a diminished capacity to deliver and extract O$_2$ during exercise.

The purpose of the study conducted by Hunter, Demment and Miller \(^45\) was to determine what effects a maintenance aerobic endurance training program, has on strength development during a strength training program. Three experimental groups of subjects were given training and one group served as controlled group. Variables were strength, endurance test, maximal oxygen consumption and anthropometric measurements. Hydrostatic weight was also measured. A 2x4x2 factorial design was used with pre-test treated as a repeated measure. Pre-test differences were almost identical for males and females. Result was strength acquisition may be inhibited during strength training mechanism if overloaded, may not be inhibited if aerobic training intensity and duration are maintained at previously established moderate levels (about 32 km/week).

Results indicate that the group that began aerobic and strength training simultaneously were at a disadvantage in development of strength.

Investigation by Prud, Homme, Bouchard, Leblanc, Landry and Fontaine\(^46\) was made to test the presence of a genotype VAT (ventilator aerobic) and MAP (maximal aerobic power) and VAT (ventilator aerobic) and VANT (ventilator and anaerobic) thresholds in ten pairs of MZ (monozygotic) twins submitted to a 20-weeks aerobic program. Ten pairs of MZ (monozygotic) twins of both sexes (6F and 4M pairs age 20±29 years) were submitted to an endurance training program, four to five times per week, 40 minutes per session and at an average were performed on cycle ergometer. MAP and VAT were measured before and after the training.

T-Test was applied to compute the data. Results suggest that there are considerable individual differences in the adaptive capacity to short term endurance training. Moreover, sensitivity of maximal aerobic power to such training is largely genotype dependent.


The purpose of the study conducted by Atomi et. al.,\textsuperscript{47} was to determine the relative importance of training intensity and frequency on the development of maximal aerobic power in young females. Thirty seven (37) female college students acted as subjects. Equipments used were Monark Bicycle Ergometer and Douglas Bag. Experimental groups were tested at the beginning and at the end of the training programme. Physiological response and VO\textsubscript{2} max were determined. Paired ‘t’ test and analysis of variance were used to determine the importance of intensity, frequency and strata. After training, VO\textsubscript{2} max was increased, the intensity is the most effective factor among three factors to increase the aerobic work capacity.

Metz and Alexander\textsuperscript{48} investigated the relationship between relative VO\textsubscript{2} max (ml/min/kg) and various physical and motor fitness test items; among the test items were pull ups and bar dips. Two age groups of 30 boys were tested (12-13 and 14-15 years). The correlations between relative VO\textsubscript{2} max and pull-ups were 0.58 and 0.52 respectively, for bar dips, the respective correlations were 0.40 and 0.46. A multiple correlation of 0.739 was obtained with pull-ups and the 50 yard dash as independent variables.

Berry, Storsteen and Woodward\textsuperscript{49} examined the effects of body mass on VO\textsubscript{2} max and efficiency. Fifty females (body mass ranging from 41.5 to 98.9 kg) served as subjects. Subjects exercised on a bicycle ergometer with no load at 60 rpm and 25, 50, 75 and 100 watts at 60 and 90 rpm. Gross VO\textsubscript{2} max and efficiency, net VO\textsubscript{2} max and efficiency work VO\textsubscript{2} max and efficiency and delta efficiency were computed. Correlational, simple linear regression and two way ANOVA were used. The results demonstrated that the body mass of an individual will significantly affect the determination of bicycle ergometer exercise VO\textsubscript{2} max and the calculation of gross and efficiency.

\textsuperscript{47} Yoriko Atomi et. al; “ Effects of Intensity and Frequency of Training on Aerobic Work Capacity of Young Females”, \textit{Journal of Sports Medicine} 18 (1978): 3-9
\textsuperscript{48} Kenneth F. Metz and John F. Alexander, “An Investigation of the Relationship between Aerobic Work Capacity and Physical Fitness in Twelve to Fifteen Year Old Boys”, \textit{Research Quarterly} 41 (March, 1970): 75
\textsuperscript{49} Michael J. Berry, Judy A. Storsteen and C. Mark Woodward, “ Effect of Body Mass on Exercise Efficiency and VO\textsubscript{2} max during Steady State Cycling”, \textit{Medicine and Science in Sports and Exercise} 25.9 (1993): 1031-1037.
net efficiency. Data suggest that body mass should be considered when estimating the oxygen uptake during bicycle ergometer exercise.

2.7 Reviews on Run/Walk Test as an Item in Fitness Test Battery

Hsien\textsuperscript{50} developed fitness norms for school-aged children in Hsinchu, Taiwan. The objectives of the study were: (a) to develop health related physical fitness norms for school-aged children and youth (ages 7 to 18 years) in Taiwan, and (b) to make age and gender comparison on each of the five physical fitness test items. The subjects involved in this study were randomly selected sample of children and youth ages 7 to 18 (N=2368) from Hsinchu, Taiwan.

The data were collected by a small, traveling group of trained physical education major students. Seven stations were established at each site to collect data. Each subject completed the following test items: (a) bent-knee sit-up test (b) pull-up test (c) height and weight measurement (d) sit-and-reach test (e) modified pull-up test (f) skinfold measurements and (g) one-mile walk/run or half mile walk/run.

Raw data were converted to percentile. The percentile scores for each test item varied by age. Data analysis (p<0.05) indicated: (1) Male students did not differ among ages for skinfold thickness. (2) Younger female students (7 to 10 years old) did not differ from older female students (16 to 18 years old) in skinfold thickness. (3) Older (16 to 18 years old) and younger (7 to 10 years old) students tended to be different in the sit-and-reach test. (4) Male students performed the higher in sit-and-reach test after age 10. (5) Male students above age 10 scored higher in the pull-up test than all female groups. (6) Male students above age 13 did not differ on the modified pull-up test. (7) Male students above age 13 did score better than all groups of female students in the one-mile walk/run test.

Cobb\textsuperscript{51} constructed a motor fitness test battery for girls in lower elementary grades. The purpose of the investigation was to construct a scientifically signed evaluative instrument for assessing the motor fitness of second and third grade girls.

\textsuperscript{50} Chun Hsien Su, “Development of Fitness Norms for School-Aged Children in Hsinchu, Taiwan”, \textit{Dissertation Abstract International 54.9} (March, 1994): 3372-A.

The subjects for the study were 183 girls from lower elementary schools in Natchitoches Parish, Louisiana.

The following listed components of motor fitness were selected: (1) muscular strength (2) muscular endurance (3) cardiovascular endurance (4) power (5) agility (6) flexibility and (7) balance.

All the test items selected for use as experimental variables were administered to the 183 subjects. The data from the administration of the experimental variables were intercorrelated using the Pearson’s product moment raw score formula. The zero-order correlation was used to construct a correlation matrix for the factor analysis, which allowed each factor analysis maximum amount of variance, thus giving identification to the item loaded highest on each factor. Those items which loaded highest on factor were selected for inclusion in the test batteries.

Two test batteries were developed from the factor analysis variance of test items purported six of the eight hypothesized components of motor fitness variables. Batteries included muscular strength, muscular endurance, cardiovascular endurance, agility, power and balance. The first battery of test included tests which loaded highest on each factor: Clarke’s strength composite, McCloy’s endurance leg extension and flexion, Well’s sit-and-reach, dodging run, Bass stick balance, and vertical jump. The second test battery testing item was substituted on two factors, thus enabling the group of test battery which could be given in a shorter time, and computation of a composite score and a ratio. Trunk flexion was substituted for Clarke’s Strength composite, and the 300-yard run with McCloy’s endurance ratio.

The findings of the study substantiated the inclusion of muscular strength, cardiovascular endurance, flexibility, agility, balance, and power components of motor fitness. The 30 test items purported to be appropriate components of motor fitness apparently were not pure measure of motor fitness elements. However, it is possible to construct a scientifically evaluated instrument for the assessment of motor fitness of second and third grade girls.
Singh and Singh 52 conducted the study to assess cardio-respiratory functions and abdominal muscular strength endurance of urban and rural senior secondary school boys of Punjab. Two thousand (2000) boys between the age of 17 and 18 years were randomly selected from senior secondary schools of Punjab State. Nine (9) minutes run and walk test and modified sit-ups test were applied for the collection of data for comparing the subjects on their cardio-respiratory function and abdominal muscular strength endurance. Analysis of variance (F-ratio) was employed and in case of significant F-ratio Least Significant Difference (LSD) test of Post-hoc differences was applied to examine significance of differences between paired means.

From the findings it was concluded that level of cardio-respiratory function and abdominal muscular strength endurance varied among 17 and 18 years rural and urban senior secondary school boys. Rural school boys were superior in cardio-respiratory functions than their urban counterparts. However, 18 years urban school boys exhibited greater abdominal muscular strength endurance as compared to their rural counterparts.

Morgan 53 conducted a study to assess the effects of two physical fitness programs on second and fifth grades children in terms of endurance, abdominal strength and flexibility. Second and fifth grade students were involved in an 8-week, 5- or 10- minute physical program. Four experimental groups (2 second and 2 fifth grades) and two control groups (1 second and 1 fifth group) were pre-tested and post-tested in the 9-minute run, sit-ups, and the sit-and-reach. The data were subjected to an analysis of variance to determine if there are significant differences in mean gains between experimental and control groups, between sexes within each group, between the 5 and 10 minute physical fitness program, and between second and fifth grade experimental groups. Results reveal significance for three experimental groups in the 9 minute run and one experimental group in the sit-ups test. The only control group in all three tests. No significance is revealed between the 5 and 10 minute program or

between the second and fifth grade control group in all three tests. No significance was revealed between the 5 and 10 minute program or between the second and fifth grade groups. The 0.05 level was utilized to determine significance.

Ghanima\textsuperscript{54} investigated the effects of a six week exercise and rope jump program on AAPHERD health related physical fitness test scores of high school females. Sixty- two students, age 15 to 16 years, enrolled in the 10\textsuperscript{th} grade physical education classes in the National Orthodox School in Amman, Jordan, during the spring semester of 1986, were subjects.

Pretest and posttest (administered according to directions outlined in the AAPHERD Test Manual) were given to two groups. One group composed of 31 students, participated in a designed exercise and rope jump program. The program consisted of warm-up, conditioning exercise, rope jump and cool down periods. The other group of 31 students participated in one or more sports activities, basketball, volleyball, team handball and ping pong.

All subjects participated in 18 sessions, three times each week for 30 minutes in a six-week period. Pre and posttest were recorded for the one-mile jog/ walk, body composition, sit-ups and flexibility test.

The following hypotheses were tested by the paired T- test, the independent samples t- test and gain sores: (1) There will be no difference between the mean pre-test and post test AAPHERD Health Related Physical Fitness Components scores of the subjects participating three times per week for a six week period in an exercise and rope jump program. (2) There will be no difference between the mean pre test and post test AAPHERD Health Related Physical Fitness Components scores of the subjects the test program and subjects participating in a regular physical education class.

Level of significance was set at the 0.05 level. The analysis of the data led to reject the first hypothesis but failed to reject the second hypothesis.

\textsuperscript{54} Sari Ahmad Ghanima, “The Effects of a Six Week Exercise and Rope Jump Program on AAPHERD Health Related Fitness Test Scores of High School Females in the Hashemite Kingdom of Jordan”, \textit{Dissertation Abstract International} \textbf{47.10} (April 1987): 3693- A.
Subjects who participated in the exercise and rope jump program scores were significantly better in all four components than subjects who participated in regular physical education classes.

Julio Morals conducted a study to ascertain the nature of physical education program in terms of the activities and their impact on the attained levels of the aerobic fitness as measured with the mile run/walk. The study comprised a secondary analysis of the national youth children and youth fitness study data 8,800 boys and girls between the age of 10 and 17. As a result, that serve predict aerobic endurance and that exposure to these factors appears to reach optimal levels, which differ depending the student’s grade level.

Curb et al. investigated the performance-based measures of physical function for high function populations. Objective of the study was to improve and broaden the applicability of performance-based measures of function for use in clinical and research settings.

The study was Cross-sectional with repeated-measures. Population-based sample of Japanese Americans without significant functional impairments aged 35 to 55 and 56 to 71 (N=203) were selected.

Measurements: Performance-based measures of physical function, including range of standard tests, newer automated measures of balance and strength and data on cognitive function, lifestyle, medical history, and physical activity.

Results: Of the nonplatform balance measures, only the one-leg stand was reliable [reliability coefficient (rc) =0.69] and able to discriminate between functional levels. Combining the Fourth National Health and Nutrition Examination Survey protocol of folded arm position while standing on a foam pad with the more-sophisticated balance platform test had the highest reliability and discrimination. With the strength chair, high rc (0.88-0.96) were found for upper and lower extremity tests. Timed chair stands, a test of lower extremity and central strength were reliable. The 6-minute walk had a high rc (0.90).

**Conclusion:** Many performance tests used today are not reliable. Only a few discriminate between the most highly functioning individuals and individuals with good function. Thus, a new recommended battery includes unassisted single-leg stand, balance platform "foam pad, eyes closed," elbow flexion and knee extension strength (strength chair), grip strength, timed chair stands, and the 6-minute walk. These simple performance-based tests have good reliability and discrimination across the range of function and can be used in most clinical and research settings to quickly assess global functional level.

### 2.8 **Reliability and Validity of Ratings of Perceived Exertion**

D. Alison Egan\(^{57}\) conducted the study to determine the reliability of a session rating of perceived exertion (RPE) scale to monitor resistance exercise intensity. Subjects (8 men, 9 women) completed two trials of acute resistance training bouts in a counter balanced design. The high intensity resistance exercise protocol consisted of six, ten-repetition sets using 75% of the one repetition maximum (RM) on a Smith machine squat and bench press exercise. The low intensity resistance exercise protocol consisted of three, ten-repetition sets at 30% of 1RM of the same exercises as the high intensity protocol. Both exercise bouts were performed with two minutes of rest between each exercise and sessions were repeated to test reliability of the measures. RPE measures were obtained using Borg’s CR-10 scale following each set. Also, a session RPE was obtained 30 minutes following each exercise session. Paired t-tests showed a significant difference between the mean RPE values for each intensity level (p<0.05). There was also a significant difference between the session RPE values for each lifting intensity (p<0.05). The intra class correlation coefficient for the session RPE measure was 0.95 and the coefficient of variation was 17%. It was concluded that the session RPE method is a valid and reliable method of quantifying resistance exercise.

---

Lamb, Eston and Corns\textsuperscript{58} assessed the test-retest reliability (repeatability) of Borg’s 6-20 rating of perceived exertion (RPE) scale using a more appropriate statistical technique that has been employed in previous investigations. The RPE scale is used widely in exercise science and sports medicine to monitor and/or prescribe levels of exercise intensity. Sixteen male athletes [mean (SD) age 23.6 (5.1) years] completed two identical multistage (incremental) treadmill running protocols over a period of two to five days. RPEs were requested and recorded during the final 15 seconds of each three minute stage. All subjects successfully completed at least four stages in each trial, allowing the reliability of RPE responses to be examined at each stage. The 95% limits of agreement (bias ± 1.96 x SDdiff) were found to widen as exercise intensity increased: 0.88 (2.02) RPE units (stage 1), 0.25 (2.53) RPE units (stage 2), -0.13 (2.86) RPE units (stage 3), and -0.13 (2.94) RPE units (stage 4). Pearson correlations (0.81, 0.72, 0.65, and 0.60) and intraclass correlations (0.82, 0.80, 0.77, and 0.75) decreased as exercise intensity increased. These findings question the test-retest reliability of the RPE scale when used to monitor subjective estimates of exercise.

Buckley, Eston and Sim\textsuperscript{59} assessed the validity and reliability of producing and reproducing a given exercise intensity during cycle ergometry using a Braille version of Borg’s 15 points ratings of perceived exertion (RPE) scale and (b) to determine whether the exercise responses of blind participants, at a given produced RPE, were similar to those reported in recognized guidelines for sighted subjects. Ten healthy registered blind volunteer participants [4 women, 6 men; mean (SD) age 23.2 (9.0) years] performed an initial graded exercise cycle test to determine maximal heart rate (HRmax) and maximal oxygen uptake (VO\textsubscript{2} max). Three trials of three exercise bouts at RPEs 9, 11, and 13 were then performed in random order on three separate days of the same week, with expired air and heart rate measured continuously. Each exercise bout was followed by 10 minutes of rest. The validity of the scale as a means of producing different exercise intensities was assessed using a two factor (RPE x trial)


repeated measures analysis of variance. Intertrial reliability was assessed using intraclass correlation coefficients (ICC) and the bias ±95% limits of agreement (95%LoA) procedure. Participants reported no difficulty in using the Braille RPE scale. When asked to produce exercise intensities equating to RPE 9, 11, and 13, they elicited mean %VO₂ max values of 47%, 53%, and 63% respectively. Analysis of variance showed no significant differences in either % or %VO₂ max between trials at each of the three RPEs, but there was a significant difference (p<0.001) in both %HR max and %VO₂ max between the three RPE levels. All pairwise comparisons of the three different RPEs were significantly different (p<0.016). The ICC between the second and third trial for % HR max was significant (p <0.05) for all three RPEs. Similarly for % VO₂ max, the ICC was significant for RPE 9 and 11 but not 13. The 95%LoA decreased for both % HR max and %VO₂ max, with each successive trial.

Blind participants were successful in using a Braille RPE scale to differentiate exercise intensity on a cycle ergometer. In every trial at RPE 13, all participants achieved %HR max and %VO₂ max, levels, which fell within the recommended range for developing cardiorespiratory fitness. Using %HR max as a judge of intertrial reliability, the participants were able to repeat similar exercise intensities after two trials at each of the three RPEs (9, 11, and 13). The same was true for RPE 9 and 11, when % VO₂ max was used as a judge, but further trials were required to achieve similar reliability at RPE 13. It was concluded that Braille RPE scale can be used by healthy blind people during cycle ergometry, with similar effect to the visual analogue scale recommended for use in healthy sighted people.

Buckley, Sim, Eston, Hession and Fox evaluated the reliability and validity of measures taken during the Chester step test (CST) used to predict VO₂ max and prescribe subsequent exercise. The CST was performed twice on separate days by 7 males and 6 females aged 22.4 (SD 4.6) years. Heart rate (HR), ratings of perceived exertion (RPE), and oxygen uptake (VO₂) were measured at each stage of the CST. RPE, HR, and actual VO₂ max were the same at each stage for both trials but each of these measures were significantly different between CST stages (p<0.0005). Intertrial

---

bias ±95% limits of agreement (95% LoA) of HR reached acceptable limits at CST stage IV (2±10 beats/min) and for RPE at stages III (0.2±1.4) and IV (0.5±1.9). Age estimated HRmax significantly overestimated actual HRmax of 5 beats/min (p = 0.016) and the 95% LoA showed that this error could range from an underestimation of 17 beats/min to an over estimation of 7 beats/min. Estimated versus actual VO$_2$ max at each CST stage during both trials showed errors ranging between 11% and 19%. Trial 1 underestimated actual VO$_2$ max by 2.8 ml/kg/min (p = 0.006) and trial 2 by 1.6 ml/kg/min (not significant). The intertrial agreement in predicted VO$_2$ max was relatively narrow with a bias ±95% LoA of -0.8±3.7 ml/kg/min. The RPE and %HRmax (actual) correlation improved with a second trial. At all CST stages in trial 2 RPE: %HRmax coefficients were significant with the highest correlations at CST stages III ($r$ = 0.78) and IV ($r$ = 0.84). CST VO$_2$ max prediction validity is questioned but the CST is reliable on a test-retest basis. VO$_2$ max prediction error is due more to VO$_2$ estimation error at each CST stage compared with error in age estimated HRmax.

The HR/RPE relation at >50% VO$_2$ max reliably represents the recommended intensity for developing cardiorespiratory fitness, but only when a practice trial of the CST is first performed.

### 2.9 Ratings of Perceived Exertion and Exercise Heart Rate

Takeshi Ueda and Takashi Kurokawa $^{61}$ investigated the validity of heart rate (f$_c$) and ratings of perceived exertion (RPE) as indices of exercise intensity in a group of children while swimming. Six healthy male swimmers, aged 10–12, swam tethered using the breast-stroke in a flume. The resistance started at 1.0 kg and increased in 1.0 kg steps up to the point of their exhaustion. The subjects swam for 5 minute during each period, with a rest of 10–20 minutes until they had returned to their resting f$_c$ level. The last exercise intensity was with the maximal mass the subjects could support for two minutes. The last minutes of oxygen consumption (VO$_2$) and 30 seconds of f$_c$ were measured during each exercise period. The subjects gave their RPE assessment at the end of exercise. The individual relationships between f$_c$ and VO$_2$,

---

and percentage maximal oxygen consumption (\(\% \text{VO}_2\text{max}\)), were linear with a high correlation \(r=0.962–0.996\) and \(r=0.962–0.996\), respectively. Therefore, it was concluded that \(f_c\) was valid as an index of the exercise intensity of children while swimming. Compared to the results found in adults using a similar protocol, the children's \(f_c\) were 8.3–26.9 beats·min\(^{-1}\) higher than those of the adults at the given \(\% \text{VO}_2\text{max}\). The study showed two different patterns in the relationship between \(\text{VO}_2\) and RPE in individuals. In two subjects the RPE increased linearly with \(\text{VO}_2\) while in the other four subjects the increase was discontinuous. If \(f_c\) and RPE were to be applied to the setting and evaluation of exercise intensity during swimming, it would seem that \(f_c\) would be a more useful guide than RPE for some children.

Patton, Morgan and Vogel \(^{62}\) conducted the study to compare the rating of perceived exertion (RPE) and heart rate (HR) in two groups of 60 military personnel who differed in their level of fitness as determined by maximal oxygen uptake (\(\text{VO}_2\text{max}\)). At an initial testing period (\(T_1\)), Group I represented a sample of personnel not participating in a training program while Group II had engaged in an endurance program (2–4 mile run/day) for 5 months. Six months later (\(T_2\)), Groups I and II were retested after having participated in the program for 6 and 11 months, respectively. RPE and HR were measured at the end of each minute of a 6-minute run at an absolute workload of 6 mph, 0% grade on the treadmill. At \(T_1\), Group II had a significantly lower HR at each minute of work but no difference existed in RPE between groups at any time during the run. At \(T_2\), both groups showed a significant decrease in HR and RPE during each minute when compared longitudinally. The data suggested that the perception of the intensity of absolute work does not differ in groups differing in their level of fitness when studied cross-sectionally. However, significant reductions in perceived exertion occur following physical training.

Karavatas and Tavakol \(^{63}\) conducted the pilot study to examine the criterion-based validity of RPE versus heart rate. Twelve fasting, healthy African-American volunteers at ages of 21-41 years performed a supervised, 45-minute brisk walk test on a treadmill over three consecutive days. Throughout the test, each subject was asked the RPE every five minutes. The subjects' heart rates were monitored continuously and recorded every minute. The overall correlation coefficient, r, between RPE and HR for all data sets (n=360) was 0.58. The ‘r’ values for males and females were 0.60 and 0.56, respectively. The analysis revealed that the correlation between RPE and HR was not as strong as previously reported, and that gender influenced the correlation. Also, RPE may be safely used to assess the exercise intensity in healthy subjects.

Perry et. al.,\(^{64}\) conducted the study to examine the heart rate (HR) responses and ratings of perceived exertion (RPE) during continuous work bouts at 80, 100, and 120% of the physical working capacity at the heart rate threshold (PWC\(_{\text{HRT}}\)). Ten men (mean age ± SD = 23.3 ± 2.9 years) performed a maximal cycle ergometer test and four, 8-minute submaximal work bouts for the determination of PWC\(_{\text{HRT}}\). Each subject then performed 3 continuous 1-hour work bouts at 80, 100, and 120% of the power output corresponding to PWC\(_{\text{HRT}}\). The results of the 1-hour work bouts showed that slope coefficients for the mean HR versus time relationships for all 3 power outputs were significantly \((p < 0.05)\) greater than zero and 0.1 bpm·min\(^{-1}\). In addition, the slope coefficients for mean RPE Versus time relationships for all 3 power outputs were significantly \((p < 0.05)\) greater than zero. The mean slope coefficients for the HR and RPE Versus time relationships indicated that the PWC\(_{\text{HRT}}\) test overestimated the maximal power output associated with steady-state HR and RPE responses. The mean HR slope coefficient suggested, however, that the PWC\(_{\text{HRT}}\) could be maintained for over 4 hours.


Dunbar et. al., conducted the study with the purpose to examine the regulation of exercise intensity by using ratings of perceived exertion (RPE). The RPE equivalent to 50% and 70% VO\textsubscript{2} max was estimated by using standard clinical protocols on a treadmill and cycle ergometer. Subjects then produced the target RPEs on these modalities. Physiological validity of perceptually regulated exercise intensity was determined by comparing heart rate between estimation and production trials at the same relative intensity. With one exception, RPE was found to be a valid means of regulating exercise intensity both intra-and intermodally at 50% and 70% VO\textsubscript{2} max. Perceptual regulation of intramodal treadmill exercise was not valid at 70% VO\textsubscript{2} max in that both VO\textsubscript{2} and heart rate were significantly lower during production than estimation. The present results also indicate that target RPE estimated during a cycle ergometer graded exercise test is more accurate for regulating exercise intensity than when the target RPE is estimated during a treadmill test. The lower accuracy found for treadmill production at the higher exercise intensity may have been caused by the use of a test protocol during the estimation trial that included relatively slow speeds and large inclines. In general, RPE provide a physiologically valid method of regulating exercise intensity.

2.10 Relationship between Running / Walking and Ratings of Perceived Exertion

Berry, Weyrich, Robergs, Krause and Ingalls investigated the ratings of perceived exertion in individuals with varying fitness levels during walking and running. The purpose of the investigation was to: (1) compare the ratings of perceived exertion (RPEs) in high and low fit individuals when walking and running at comparable exercise intensities and (2) to determine if ventilation (V\textsubscript{E}) provides a central signal for RPEs.

---

Nine high fit and nine low fit male subjects completed two exercise bouts on a treadmill, one uphill walking and the other level running. Workloads for each bout were set at 90% of each subject's ventilatory threshold (VT) as determined from a graded exercise test. Oxygen consumption (VO$_2$) heart rate (HR), and V$_E$ were all similar between the walk and run trials for the low fit subjects ($P>0.05$). HR were found to be significantly greater during the walk trial versus the run trial ($P<0.05$) for the high fit subjects, whereas, V$_E$ was significantly greater during the run trial. Oxygen consumption was similar for the high fit subjects during both trials ($P>0.05$). During the walk and run trials, central (12.1±.6 versus 11.4±1.5), local (14.0±1.3 versus 13.9±1.1) and overall (12.8±1.2 versus 12.4±1.4) RPEs were not found to be significantly different for the low fit group ($P>0.05$). In contrast, during the walk versus the run trial there was a significant increase in central (10.7±2.0 versus 9.2±1.9), local (11.5±2.0 versus 9.8±1.8) and overall (11.2±2.4 versus 9.6±2.3) RPEs for the high fit group ($P<0.05$).

There were significant differences ($P<0.05$) when comparing local, central and overall RPEs during both the walk and run trials for the low fit group with local RPEs being significantly greater than both central and overall RPEs. There was no significant difference ($P>0.05$) between central and overall RPEs in either the walk or run trial for the low fit group. No significant differences ($P>0.05$) were found between the central, local and overall RPEs for either the walk or run trial with the high fit group. Based on the results, it appeared as if walking is perceptually more stressful than running at similar exercise intensities for high fit individuals. Since V$_E$ was greater for the run trial versus the walk trial for the high fit subjects, yet RPEs were lower, it does not appear as if V$_E$ provides a central signal for the determination of RPEs.

Grant et. al.,$^{67}$ compared the physiological responses and rating of perceived exertion in two modes of aerobic exercise in men and women over 50 years of age.

---

Objectives: To compare the physiological responses and ratings of perceived exertion to aerobic dance and walking sessions completed at a self selected pace.

Methods: Six women and six men with a sample mean (SD) age of 68 (7) years completed aerobic dance and walking sessions in random order. A treadmill test was performed by each subject from which peak oxygen uptake (VO$_2$) and maximum heart rates (HRmax) were determined. During the aerobic dance and walking sessions, heart rate and VO$_2$ were measured continuously throughout. Rate of perceived exertion (RPE) was measured every three minutes throughout the session.

Results: The sample means (SD) for % peak VO$_2$ were 67 (17) % for the aerobic dance sessions and 52 (10) % for the walking sessions, and the %HRmax sample means (SD) were 74 (12) % for the aerobic dance sessions and 60 (8) % for walking sessions. The sample mean (SD) RPE for the aerobic dance sessions was 11 (2), and for the walking sessions it was 10 (2).

Conclusions: %peak VO$_2$, % HR max, and RPE were significantly higher for aerobic dance than for walking. However, both the aerobic dance and walking sessions were of adequate intensity to improve aerobic fitness in most subjects. Further investigation into the relation between RPE and %peak VO$_2$ in a field setting over representative exercise time periods would be useful.

Katsanos and Moffatt$^{68}$ studied the reliability of heart rate responses at given ratings of perceived exertion in cycling and walking. Eleven healthy men (Mean age = 27 years, SD = 4 years) completed three cycling and three walking trials in an alternating order. During each trial, participants were allowed, within three minute, to adjust the work rate to correspond to given rating of perceived exertion (RPE) values according to the following order: RPE 11, 13, and 15. For cycling as well as walking, at each RPE there were no significant differences between mean heart rate responses across the three trials (p >0.05). Mode-specific estimates for heart rate intraclass correlation coefficient and coefficient of variation ranged between 0.80 and 0.91, and 5.6% and 8.3%, respectively. This study provided absolute reliability estimates for heart rate responses when using RPE in a production format and suggests there may

---

be RPE- (and mode) specific practice requirements for achieving a reliable heart rate response at a given RPE.

Backward walking has gained popularity as an adjunct to treatment for patients undergoing rehabilitation for patellofemoral pain syndrome and anterior cruciate ligament injuries. Researchers have suggested that backward walking decreases the compressive forces at the patellofemoral joint while also preventing overstretching of the anterior cruciate ligament.

Erica Clarkson et al.,\textsuperscript{69} studied the oxygen consumption, heart rate, and rating of perceived exertion in young adult women during backward walking at different speeds. The purpose of this study was to determine the relationship between heart rate, oxygen consumption, and backward walking speeds. Twenty-five healthy, adult female volunteers participated in this study. Subjects were tested at speeds of 0.96, 1.20, 1.43, 1.67, and 1.91 m/sec. Subjects also performed a graded exercise stress test. Analysis revealed curvilinear relationships between oxygen consumption and speed as well as between heart rate and speed. With these results, clinicians may now prescribe specific speeds of backward walking for women to elicit a desired cardiopulmonary response.

The purpose of the study conducted by Kavita\textsuperscript{70} was to study rating of perceived physical exertion of kabaddi players. Forty-two male kabaddi players were selected from university of Delhi. The age of the players ranged from 17 to 24 years, with mean age 21.72 ± 2.44 (mean ± standard deviation) and mean weight 63 ± 9.73 (mean ± standard deviation). Exercise heart rate was recorded by polar heart rate monitor (PHRM) while Cooper’s 12 minutes run/walk test was administered. The obtained data was subjected to mean, maximum scores, minimum scores, standard deviation and product moment correlation computation. From the findings it was concluded that rating of perceived exertion (RPE) was related to heart rate, volume of exercise, and intensity of exercise of male kabaddi players.


\textsuperscript{70}Kavita, “A Study on Rating of Perceived Physical Exertion of Kabaddi Players”, Unpublished Master Degree Dissertation, University of Delhi, (June 2009).
Singh \textsuperscript{71} conducted the study to assess the correlation between volume, intensity of physical activity and rating of perceived exertion on female judo players on twelve minute run walk paradigm. Thirty female judo players were randomly selected from university of Delhi. The age of female judo players were ranged from 17 to 24 years, with mean age 21.72 years and mean weight 53 kilograms. The subjects were asked to cover maximum distance in 12 minutes either by running or walking on well-marked 100 meter straight (marked at an interval of 10 meters). Heart rate and RPE were recorded at an interval of each 200 meters of distance during Cooper’s 12 minutes walking/running test. The obtained data was subjected to mean, maximum scores, minimum scores, standard deviation and product moment correlation computation. From the findings it was concluded that rating of perceived exertion (RPE) were related to heart rate, volume of exercise and intensity of exercise of female judo players.

Pathak \textsuperscript{72} aimed to verify correlation among volume and intensity of physical activity and rating of perceived physical exertion of male judo players. Forty four male judo players were randomly selected from university of Delhi. The age of players ranged from 17 to 24 years (mean ± SD) with mean age 21.72 ± 2.44 years and mean weight 63±9.73 kilograms. The subjects were asked to cover maximum distance in 12 minutes either by running or walking on well-marked 100 meter straight (marked at an interval of 10 meters). Heart rate and RPE was recorded at an interval of each 200 meters of distance during Cooper’s 12 minutes walking/running test. The obtained data was subjected to mean, maximum scores, minimum scores, standard deviation and product moment correlation computation. The findings documented significant relationship between RPF and velocity (intensity) at 200 and 400 meters of distance, RPE and heart rate at 600, 800, 1000, 1200, 1400, 1600, 1800 and 2400 meters of distance, RPE and Split time at 400 meters, 600 meters and 800 meters of distance velocity and heart rate at 800 meters, velocity and split time at 200

\textsuperscript{71} Anidev Singh, “The Volume and Intensity of Physical Activity Correlates Rating of Perceived Exertions on Female Judo Players on Twelve Minute Run and Walk Paradigms”, Unpublished Master Degree Dissertation, University of Delhi, (June 2009).

\textsuperscript{72} Madhavi Pathak, “The Volume and Intensity of Physical Activity Correlation Rating of Perceived Physical Exertion of Male Judo Players” Unpublished Master Degree Dissertation, University of Delhi, (June 2009).
meters, 400 meters, 600 meters, 800 meters, 1000 meters, 12 meters, 1400 meters, 1600 meters, 1800 meters, 2000 meters, 2200 meters and 2400 meters of distance. The intensity remained same throughout the 12 minutes run/walk test except last 200 meters. The heart rate in early distances correlated to the volume of exercise, the RPE strongly related to volume of exercise.

2.11 Other Related Studies

Leugh and Montagomery \(^{73}\) conducted a study to examine the efficacy of 12 Minute Stationary Cycle Ergometer Test (12 MSCET) in relation to VO\(_2\) max (adjusted for body weight) for fit college age men, using 1.2 or a combination of the two kilo pound, sixty male subjects from the US Military Academy. The test points were VO\(_2\) max tested using a metabolic chart to determine VO\(_2\) max for cycling. Two days later, they took the 12 MSCET, 30 cadences at 2.5 kp and the other 30 cadences at 3.0 kp. Total work done in 12 minutes and body weight were used in a multiple regression format to predict relative VO\(_2\) max. Four models were developed: one for each kp setting (2.5 and 3.0 models); one for the entire sample; and one for the weight resistance matched sample WT-RES Model, those above the mean weight of the all subjects; those who rode at 3.0 and those below the mean weight at 3 kp. Possible non linear ties, interactions and assumptions were investigated. It was concluded that 12 MSCET can be a accurate in estimation of VO\(_2\) max not only with a universal working of 2.5 kp for use with normal aged males, but in a weight resistance matched format which can be better applied to large fit college aged male subjects.

Ritchie et. al., \(^{74}\) examined the reliability and validity of field tests for assessing physical function in mid-aged and young-old people (55-70 years). Tests were selected that required minimal space and equipment and could be implemented in multiple field settings such as a general practitioner's office. Nineteen participants completed 2 field and 1 laboratory testing sessions. Intra-class correlations showed good reliability for the tests of upper body strength (lift and reach, R= .66), lower

---


body strength (sit to stand, $R = .80$) and functional capacity (Canadian Step Test, $R = .92$), but not for leg power (single timed chair rise, $R = .28$). There was also good reliability for the balance test during 3 stances: parallel (94.7% agreement), semi-tandem (73.7%), and tandem (52.6%). Comparison of field test results with objective laboratory measures found good validity for the sit to stand (cf 1RM leg press, Pearson $r = .68$, $p < .05$), and for the step test (cf PWC140, $r = -.60$, $p < .001$), but not for the lift and reach (cf 1RM bench press, $r = .43$, $p > .05$), balance ($r = -.13$, -.18, .23) and rate of force development tests ($r = -.28$). It was concluded that the lower body strength and cardiovascular function tests were appropriate for use in field settings with mid-aged and young-old adults.

Benton and Alexander\(^75\) validated functional fitness tests as surrogated for strength measurement in frail, older adults with chronic obstructive pulmonary disease.

**Objective:** This study evaluated the relationship of functional field tests to traditional laboratory strength tests in 40 frail, older adults with chronic obstructive pulmonary disease.

**Design:** Participants completed two trials of upper (chest press) and lower (leg press) body maximal strength (maximal weight lifted one time) testing and one trial of functional fitness testing (arm curl, lift and reach, chair stand, up and go). The maximal weight lifted one-time values from both trials were compared with functional fitness test values to identify valid surrogates.

**Results:** Among upper-body functional fitness tests, the arm curl had a moderately strong relationship to chest press (trial 1: $r = 0.55$, $P = 0.01$; trial 2: $r = 0.56$, $P = 0.01$) whereas the lift and reach did not. Among lower-body functional fitness tests, the chair stand had a fairly strong relationship to leg press (trial 1: $r = 0.46$, $P = 0.01$; trial 2: $r = 0.38$, $P = 0.05$), but the Up and Go did not.

**Conclusions:** Only the arm curl and chair stand tests were valid surrogates. Although multiple field tests to measure strength in a clinical setting may be

---

desirable, these data support limiting functional testing to the arm curl for upper-body and the chair stand for lower-body strength assessment.

Willmore 76 investigated cardiovascular responses to treadmill and cycle ergometer exercise in children and adults. In study one, submaximal cardiovascular responses to exercise were compared between young boys and girls to see if a gender difference was present and to see if exercise modality affected this comparison. In study two, submaximal cardiovascular responses to exercise were compared between boys versus men and girls versus women on both the treadmill and cycle ergometer. In study three, they determined if there were differences in submaximal cardiovascular responses at a given oxygen consumption level between the treadmill and cycle ergometer in children and adults. In study one, it was found that the submaximal cardiovascular responses in young boys and girls were essentially the same, and exercise modality did not affect this comparison. In study two, it was found that there were significant differences in submaximal cardiovascular responses between boys versus men and girls versus women. Furthermore, this difference was present in both the treadmill and cycle ergometer. In study three, it was found that at a given rate of oxygen consumption there were no significant differences in submaximal cardiovascular responses to exercise between the treadmill and cycle ergometer in adults with only minor differences in young children.

Stanley77 conducted the study to prove the validation of the 12-minute swim as a field test of maximal aerobic power. The purpose of the study was to validate the 12-minute swim as a field test of maximal aerobic (VO\textsubscript{2} peak). Other objectives were to compare the validity of the 12-minute swim and run as field tests of VO\textsubscript{2} peak and VO\textsubscript{2} max, and to determine the relative importance of VO\textsubscript{2} peak, swimming economy (VO\textsubscript{2} measured at 0.65m.sec\textsuperscript{-1}), and % VO\textsubscript{2} peak used at the average 12-minute swim velocity in accounting for individual differences in 12-minute swim performance. Thirty-six male recreational swimmers completed 12-minute swim and run tests, tethered swimming VO\textsubscript{2} peak and uphill treadmill running VO\textsubscript{2} max tests, and

76 H. Willmore, “Cardiovascular Responses to Treadmill and Cycle Ergometer Exercise in Children and Adults”, Dissertation Abstract International 56.6 (December, 1995):2168-A.
77 [http://medind.nic.in/imvw/imvw5900.html](http://medind.nic.in/imvw/imvw5900.html)
assessments of swimming economy and % VO$_2$ peak used at the average 12-minute swim velocity within a three-week period, relation coefficients and standard errors of estimate from prediction of tethered swimming VO$_2$ peak from the 12-minute swim (.45 and 5.7 ml.kg BW$^{-1}.min^{-1}$), treadmill running VO$_2$ max from 12 minute swim (.88 and 2.6 ml.kg BW$^{-1}.min^{-1}$), tethered swimming VO$_2$ peak from the 12-minute run (.79 and 4.2 ml.kg BW$^{-1}.min^{-1}$), indicated that the 12 minute run is more valid predictor of maximal aerobic power than the 12-minute swim, regardless of whether VO$_2$ peak was measured during running or swimming. The primary reason the 12-minute swim performance was influenced by variation in swimming economy ($r$=-.65). The combination of VO$_2$ peak and swimming economy accounted by the variance in 12-minute swim performance, compared to the accounted for by VO$_2$ peak alone. Estimates of the average in 12-minute swim performance accounted for by swimming (52%), VO$_2$ peak (26%) and % VO$_2$ peak utilized during the swimming with combinations of the other independent variables held indicated that swimming economy was the most important measure determinant of 12-minute swim performances, followed by VO$_2$ peak and % VO$_2$ peak utilized. It was concluded that unlike the 12-minute run, the 12-minute swim does not have acceptable validity and test of maximal aerobic power in young male recreational swimming.

Huse et al. conducted the study with the purpose to examine the validity and reliability of the Cooper 12-minute swim test in high school male swimmers ages 13 to 17. Thirty-three boys performed three 12-minute swims and 1 maximal graded treadmill test within a 14-day period. One practice swim was conducted 1 week prior to participation in this study.

VO$_2$ max was assessed by indirect calorimetry with open-circuit spirometry with the Truemax 2400 metabolic cart (Consentius Technologies, Sandy, UT). Test–retest reliability of the 12-minute swim assessed via one-way analysis of variance indicated moderate reliability [$R$=.66, 95% confidence interval (CI) = .42–.81], whereas concurrent validity assessed via a Pearson product–moment correlation indicated a moderate relation ($r$ = .47, 95% CI = .15–.70, $r^2$ = .22). Results indicate that the Cooper 12-minute swimming test is only moderately reliable after 2 practice
swims and does not appear to be a valid field test of aerobic capacity in high school male swimmers ages 13 to 17.

2.12 Summary of the Review of the Related Literature

The exhaustive review of literature concluded with a total Seventy five (75) citations under eleven subheadings. The reviews to support “A Study on the Validation of Cooper’s Twelve Minute Run and Walk Test for Selected Male Populations of NCT-Delhi” may be summarized as following

2.12.1 Scientific Authenticity of Twelve Minute Run and Walk Test for Different Populations

The research scholar listed fourteen researches on the scientific authenticity of twelve minute run and walk test as following:

i. A means of assessing maximum oxygen uptake.
ii. The twelve minute run-walk: A test of cardiovascular respiratory fitness of adolescent boys.
iii. Validation of running tests of 4, 8 and 12 minutes duration in estimating aerobic power for college women of different fitness level.
iv. A study of the validity and reliability of the twelve minute run under selected motivational conditions.
v. Validation of Cooper’s 12 minute run test for estimation of aerobic capacity ($\text{VO}_2 \text{max}$).
vi. The accuracy of six minute run test to measure cardiorespiratory fitness.
vii. Relationship between walk/run performance and cardiorespiratory fitness in adolescents who are overweight.
viii. Evaluation of Cooper’s 12- minute walk/run test as a marker of cardiorespiratory fitness in young urban children with persistent asthma.
ix. A comparison of methods of predicting maximum oxygen uptake.
x. A study to determine the relationship between physical fitness and maximal work capacity, professional activity skill level, and scholastic aptitudes of physical education majors.
xi. The validity of predicting the maximal oxygen uptake of young females using selected submaximal estimators.

xii. Predictors of 6-minute walk test and 12-minute walk/run test in obese children and adolescents.

xiii. Analysis of walk tests as indicators of aerobic capacity.

xiv. Development of a 12-minute treadmill walk test at a self-selected pace for the evaluation of cardiorespiratory fitness in adult men.

2.12.2 Validation of Different Run/Walk Tests for Different Populations

The research scholar critically reviewed twelve research studies on the validation of different run/walk tests other than 12 minute run/walk test.

i. Criterion-related validity of field-based fitness tests in youth.


iii. To determine the validity and reliability of the 1,000 meters walk-run test in adults.

iv. Validity and reliability of a timed 5 kilometer cycle ergometer ride to predict maximum oxygen uptake.

v. Criterion validity of a two-kilometer walking test for predicting the maximal oxygen uptake of moderately to highly active middle-aged adults.

vi. Validation of criterion-referenced standards for the mile run test and multistage fitness test.

vii. Validity and reliability of the half-mile run-walk as an indicator of aerobic fitness in children with mental retardation.

viii. Criterion related validity of ½ mile run/walk (1/2 MRW) test for estimating VO$_2$ peak in children aged 6-17 years.

ix. Criterion-related validity of the one-mile run/walk test in children aged 8-17 years.

x. Validation of two running tests as estimates of maximal aerobic power in children.

xi. A qualitative systemic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain.

xii. The six-minute walk test in healthy children: reliability and validity.
2.12.3 Reviews on One Mile Jog Test
Following four studies highlight the scientific authenticity of one mile jog test.

i. VO$_2$ max estimation from a submaximal one mile jog for fit college age individuals.

ii. Estimation of VO$_2$ max – a comparative analysis of five exercise tests.

iii. A comparison of field methods to assess Cardiorespiratory fitness among Neophyte exercisers.

iv. Treadmill validation of an over ground willing test to predict peak oxygen consumption.

2.12.4 Effects of Run and Walk Exercise Programmes
Following three research articles were reviewed related to effects of running and walking exercise programmes on cardio-respiratory fitness, body composition, self-concept, body image, obesity, muscular strength, endurance and flexibility variables.

i. Changes in cardio-respiratory fitness and body composition of participants in selected physical education classes.

ii. The effects of a twelve minute aerobic training program on second and fourth grade students.

iii. The effects of eight week structured walking/jogging program on the cardiovascular fitness, self-concept and body image of mildly retarded adults.

2.12.5 Relationship among Cardiorespiratory Fitness, Physiological Parameters and Run and Walk Tests
Following seven research reviews related to relationship between Cardiorespiratory fitness, physiological parameters and run and walk tests are listed. Among these reviews body weight, height, body fat percentage, cardiovascular fitness, maximal oxygen consumption, BMI, muscle enzyme activity and muscle fiber composition were the independent variables whereas run and walk performance, heart rate and maximal oxygen consumption were the dependent variables.
i. Determinates of running and walking endurance performance in children: a path model.

ii. A study of the relationship between cardiovascular fitness and the number of heart beats accumulated by college men during work of selected intensity.

iii. Heart rate response of children to four separate bouts of running.

v. The relationship of selected physiological, training, and performance measures to distance running performance.

vi. The relationship between fifth and sixth grade children’s maximal oxygen intake and running performance at selected distances.

vii. Optimal duration of a heavy work endurance test in relation to oxygen intake capacity.

viii. Relationship of single measures of cardiorespiratory fitness and obesity in young school children.

2.12.6 Different Physiological Variables as Independent Variables and VO$_2$ Max as Dependent Variable

Following six research reviews related to relationship between different physiological independent variables e.g. hemodynamic factors, strength, ventilator aerobic threshold and ventilator anaerobic threshold and maximal oxygen consumption are listed.

i. Physiological factors associated with the lower maximal oxygen consumption of master runners.

ii. Development of strength and maximum oxygen during simultaneous training for strength and endurance.

iii. Sensitivity of maximal aerobic power to training in genotype dependent.

iv. Effects of intensity and frequency of training on aerobic work capacity of young females.

v. An investigation of the relationship between aerobic work capacity and physical fitness in twelve to fifteen year old boys.

vi. Effect of body mass on exercise efficiency and VO$_2$ max during steady state cycling.
2.12.7 Reviews on Run/Walk Test as an Item in Fitness Test Battery

The research scholar listed seven research reviews where run and walk tests are included as an item in different test batteries.

i. Development of fitness norms for school-aged children in Hsienchu, Taiwan.

ii. The construction of motor fitness test battery for girls in lower elementary grades.

iii. Assessment of cardio-respiratory functions and abdominal muscular strength endurance of urban and rural school boys of Punjab.

iv. A study of the effects of two physical fitness programs on second and fifth grade children in terms of endurance, abdominal strength and flexibility.

v. The effects of a six week exercise and rope jump program on AAPHERD health related fitness test scores of high school females in the Hashemite kingdom of Jordan.

vi. The effects of aerobic exercise on cardiovascular reactivity and baroflex responses in women with parental history of hypertension.

vii. Performance-based measures of physical function for high function populations.

2.12.8 Reliability and Validity of Ratings of Perceived Exertion

The research scholar cited four research reviews proving scientific authenticity of ratings of perceived exertion.

i. Session rating of perceived exertion during high intensity and low intensity bouts resistance exercise.

ii. Reliability of ratings of perceived exertion during progressive treadmill exercise.

iii. Ratings of perceived exertion in braille: validity and reliability in production mode.

iv. Reliability and validity of measures taken during the Chester step test to predict aerobic power and to prescribe aerobic exercise.
2.12.9 Ratings of Perceived Exertion and Exercise Heart Rate

Relationship between ratings of perceived exertion and exercise heart rate has been shown through the following five citations.

i. Validity of heart rate and ratings of perceived exertion as indices of exercise intensity in a group of children while swimming.

ii. Perceived exertion of absolute work during a military physical training program.

iii. Concurrent validity of Borg’s ratings of perceived exertion in African-American young adults, employing heart rate as the standard.

iv. Heart rate and ratings of perceived exertion at the physical working capacity at the heart rate threshold.

v. The validity of regulating exercise intensity by ratings of perceived.

2.12.10 Relationship between Running / Walking and Ratings of Perceived Exertion

The research scholar critically reviewed seven research reviews establishing the relationship between running / walking and ratings of perceived exertion.

i. Ratings of perceived exertion in individuals with varying fitness levels during walking and running.

ii. A comparison of physiological responses and rating of perceived exertion in two modes of aerobic exercise in men and women over 50 years of age.

iii. Reliability of heart rate responses at given ratings of perceived exertion in cycling and walking.

iv. Oxygen consumption, heart rate, and rating of perceived exertion in young adult women during backward walking at different speeds.

v. A study on rating of perceived physical exertion of kabaddi players.

vi. The volume and intensity of physical activity correlates rating of perceived exertions on female judo players on Twelve minute run and walk paradigms.

vii. The volume and intensity of physical activity correlation rating of perceived physical exertion of male judo players.
2.12.11 Other Related Studies

The research scholar listed six other research reviews related to the study.

i. Effect of 12 minute stationary cycle ergometer test and prediction of VO$_2$ max in fit, college- aged men.

ii. Reliability and validity of physical fitness field tests for old- aged 55-70 years.

iii. Validation of functional fitness tests as surrogated for strength measurement in frail, older adults with chronic obstructive pulmonary disease.


v. Validity of the 12-minute swim as a field test of maximal aerobic power.

vi. To examine the validity and reliability of the Cooper 12-minute swim test in high school male swimmers ages 13 to 17.

2.13 Conclusions Drawn from the Review of the Related Literature

2.13.1 Scientific Authenticity of Twelve Minute Run and Walk Test for Different Populations

1. Cooper (1968) found 12 minute run and walk test as highly valid and reliable test to assess maximal oxygen uptake. He also developed norms of 12 minutes run and walk test for male and female independently of the age categories 13-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years and 60 above years.

2. Doolittle and Bigbee (1965) concluded that the distance a junior high school boy can cover in twelve minutes is a reliable and more valid indicator of his cardiovascular fitness than the 600 yard test.

3. Dorociak (1981) found that the 12 minute run had the highest correlation with VO$_2$ max for the beginning runners. For the intermediate runners, any of the three distance runs can be used with equal confidence to estimate aerobic power. The 8 min run had the strongest relationship with VO$_2$ max for the more advanced runners. When the data from all the groups were pooled, the correlation between VO$_2$ max and the three runs were quite high and essentially the same (4-min $r=0.86$, 8 min run $r=0.87$ and 12-min run $r=0.89$).
4. Wanamaker (1970) concluded that the twelve minute run was not an effective predictor of maximum intake of oxygen. The twelve minute run was considered a reliable measure. The social facilitation treatment (running in groups) and the conditions under which the twelve minute run was administered (volunteer or class subjects) were not effective in producing significantly different performances.

5. Iqbal and Ghosh (1999) observed that the correlation coefficient of relative VO\textsubscript{2} max and 12 min run test was 0.76. The test-retest correlation was found to be 0.85 with SEE of 3.59. This denotes that the VO\textsubscript{2} max of the sports persons in the age group of 14-18 years can be predicted from 12 min run test with an accuracy of ±6.5 percent.

6. Bolonchuck found the correlation coefficient (r=0.85) between the 6-minute test scores and the 12- minute test scores.

7. Drinkard et.al., (2001) suggest that an easily obtained measurement of physical performance (distance traveled during a 12-minute walk/run test) is related to cardiorespiratory fitness and to body composition in adolescents who are overweight. The 12-minute walk/run distance is more predictive of cycle ergometry test results than the 9-minute distance.

8. According to Weisgerber et. al., (2009) Cooper’s twelve minute run and walk test and maximal oxygen consumption were moderately correlated (pre-intervention: 0.55, \(P = 0.003\); post-intervention: 0.48, \(P = 0.04\)) as one-time measures of fitness. Correlations of the tests as markers of change over time were poor and insignificant. Hence it was concluded that in children with asthma, Cooper’s twelve minute run and walk test is a reasonable one-time estimate of fitness but a poor marker of fitness change over time.

9. Grant, Corbett, Amjad, Wilson, and Aitchison (1995) found that the Cooper test had a correlation with the treadmill test of 0.92, while the Multi Stage Test (MST) and the predicted submaximal cycle ergometer test (L/E) had correlations of 0.86 and 0.76 respectively. Both the MST and predicted L/E showed systematic under prediction of the treadmill value. On average, the MST was 4.5 ml.kg.\textsuperscript{-1}min.\textsuperscript{-1} (s.d. 0.9) lower than the treadmill VO\textsubscript{2} max while the predicted L/E was 7.8 ml.kg.\textsuperscript{-1}min.\textsuperscript{-1} (s.d. 1.4) lower than the treadmill VO\textsubscript{2} max. These findings indicate
that, for the population assessed, the Cooper walk run test is the best predictor of VO$_2$ max among the three tests.

10. In the study conducted by Tsai (1972) all physical fitness variables intercorrelated significantly (p≤0.05) except VO$_2$ max and dips. Test-retest reliability of the variables was significant at 0.01 level. According to Tsai VO$_2$ max can be adequately predicted ($R^2 \geq 0.50$) in physical education majors from dips, weight, sit-ups and 12 minute run, with 12 minute run the best single predictor. There was a significant but low relationship between physical fitness and specific sport skill in professional activity (based upon ratings by experts). There were no relationships between physical fitness scholastic aptitude and professional activity skill based upon ratings by experts.

11. Taylor (1980) concluded that for the non-trained females, 18 to 20 years of age, the Astrand-Rhyning nomogram and the Margaria nomogram were not valid measures of VO$_2$ max when using a step-test workload protocol. Furthermore, there was a large absolute prediction error introduced by using these protocols. It was also concluded that the twelve-minute run/walk, although appearing to be reliable, may not be a valid indicator of maximal oxygen uptake in untrained females.

12. Patrick et. al.,(2008) found that in obese children and adolescents BMI z-score is the most dominant predictor of the variability in performances on the 6-minute walk test and the 12-minute walk/run test at admission as well as after 3 months of treatment.

13. The study conducted by Vickers, revealed that for adults, the average walk test performance-VO$_2$max correlation was $r = .56$ for a 6-min walk, $r = .74$ for a 12-min walk, $r = .57$ for a 1-km walk, $r = .64$ for a 1-mile walk, and $r = .64$ for a 2-km walk. Each average value was highly significant, so the review was extended to consider multivariate equations combining walk test performance with age, weight, gender, and exercise heart rate to predict VO$_2$ max. These equations have predicted VO$_2$ max accurately and cross-validate well. The standard error of estimate (SEE) for VO$_2$ max predictions from these equations was only 0.32 to 0.40 ml·kg$^{-1}$·min$^{-1}$ larger than that for equivalent statistic for run tests. Walk tests
are valid and are comparable to run tests as indicators of VO\textsubscript{2} max when the multivariate approach is used.

14. Masaki Nakagaichi and Kiyoji Tanaka (1998), suggest that the 12-min submaximal treadmill walk test (STWT) is a valid method for the assessment of VO\textsubscript{2} peak and VO\textsubscript{2AT}. Therefore, the STWT could be a useful performance test for evaluating cardiorespiratory fitness in middle age, older, sedentary individuals and patients with chronic disease.

2.13. 2 Validation of Different Run/Walk Tests for different Populations

1. Jose et.al., (2009) found moderate evidence that the 1-mile run/walk test is a valid test to estimate cardiorespiratory fitness.

2. According to Ross and Vickers validity was higher for fixed-time runs than for fixed-distance runs and in samples with greater variability in VO\textsubscript{2} max. This difference must be interpreted cautiously because studies that directly compared these two types of run test have found little or no difference. Validity was not related to the age, gender, fitness, or running experience of the population tested or to the method used to measure VO\textsubscript{2} max. The evidence was consistent with the view that some methods factors affect run test validity, but tests are equally valid for different types of people.

3. Diaz et al., (2000) concluded that the 1,000 meters distance walk-run time is highly reliable and valid test for estimation of VO\textsubscript{2} max in Mexican people.

4. Michael J Buono (1996) suggests that a timed five kilometer cycle ergometer ride is a valid and reliable predictor of (VO\textsubscript{2}). Furthermore, the timed cycle ride offers several methodological advantages which make it potentially useful in clinical, military, and research settings.

5. Laukkanen (1999) suggest that the two kilometer walk test is a reasonably valid test of maximal aerobic power for moderately fit men and women, but less valid for very fit individuals.

6. For the study of Lai (1995) final resulting optimal cutting scores obtained included 11:00 minutes for the boys mile run, 12:30 minutes for the girls mile run, 26 laps for the boys multistage fitness test, and 22 laps for the girls multistage fitness.
7. According to Fernhall et. al., the test-retest correlations were $r = .90$ for VO$_2$ max, $r = .81$ for maximal heart rate, and $r = .96$ for the 1/2-mile run-walk ($p < .05$). The correlation between VO$_2$ max and the half-mile run-walk was $r = -.60$ ($p < .05$). Adding body mass index to the model improved R to .67 (SEE = 7.3). The 1/2-mile run-walk was a reliable test, but had questionable validity as an indicator of aerobic capacity in children with mild and moderate MR.

8. Castro et. al., (2009) computed and assessed through several error measures, and the Bland and Altman method. In conclusion, the new regression equation was valid for estimating VO$_2$ peak from the half-mile run-walk time, sex, and body mass index in healthy children aged 6-17 years, and was more accurate than Fernhall's equation in the sample studied.

9. Jose et. al.,(2009) computed the correlation coefficient between measured VO$_2$ peak and one-mile run/walk time was 0.59 ($P < 0.001$) and that between measured and estimated VO$_2$ peak was 0.70 ($P < 0.001$). The mean difference between measured and estimated VO$_2$ peak was 10 ml·kg$^{-1}$·min$^{-1}$ (95% CI = 9.2-11.8; $P < 0.001$). The standard error of the estimate was 3 ml·kg$^{-1}$·min$^{-1}$, and the percentage error was 32%. There was a positive association between the measured and estimated VO$_2$ peak difference and the measured and estimated VO$_2$ peak mean, which indicates that the higher the VO$_2$ peak the higher the error of the estimate. These findings did not change markedly when the analyses were performed by sex, age group or body mass status. These results suggest that Cureton's equation systematically underestimates VO$_2$ peak in endurance-trained children with high VO$_2$ peak.

10. According to Mechelen, Hlobil, and Kemper (1986) 20 meters shuttle run test (MST) is a suitable tool for the evaluation of maximal aerobic power. Although the differences in validity between the 20-MST and the six minutes endurance run were statistically not significant ($p > 0.05$), for reasons of practicability the 20-MST should be preferred to the six minutes endurance run when used in physical education classes.

11. According to Li et. al., (2005) in healthy children, the six minute walk test is a reliable and valid functional test for assessing exercise tolerance and endurance.
12. According to Butland, Pang, Gross, Woodcock and Geddes (1982) the review of functional walking tests concluded that the six minute walk test (6MWT) is easier to carry out, more acceptable and provides a better reflection of activities of daily living than other walk tests.

2.13. 3 Reviews on One Mile Jog Test

i. George (1993) concluded that a submaximal one mile track jog can accurately predict VO$_2$ max and is a viable alternative to maximal performance test such as 1.5 mile run.

ii. The study by Zwiren et. al., (1991) suggest that both the run and walk tests viz. 1.5 mile run and a mile walk are satisfactory predictors of VO$_2$ max in 30-39 years old females.

iii. Data from Karen, Kate and Vincent’s (2006) preliminary study suggest that both the Rockport 1-mile and a nonexercise estimation of VO$_2$ max test are comparable to the Queen’s College Step Test as valid and reliable field measures of aerobic fitness and appear to be good alternatives to step testing among sedentary individuals.

iv. According to Widrick et. al., the over-ground walking test, when administered on a treadmill, is a valid method of predicting VO$_2$ peak but under predicts VO$_2$ peak of subjects with observed high VO$_2$ peak values.

2.13. 4 Effects of Run and Walk Exercise Programmes

i. According to Serfass (1972) VO$_2$ max improved significantly in all three activity groups. Regression equations, developed to predict VO$_2$ max, produced $R^2$ ranging from 0.10 to 0.64. The best subset variables for the prediction of VO$_2$ max was a pre-test subset containing body weight, 600 yard run-walk test, and 12 minute run-walk test ($R^2= 0.635$, standard error of estimate 3.615 cc/kg BW/min.).

ii. According to the results of the study by Renfrow (1981) the conclusion was that an aerobic training program has little or no effect on cardiovascular endurance in elementary school children. However, the aerobic program does not have a significant effect on percentage of body fat.
iii. Davey (1987) indicate that an eight week structured walk-jogging program has a positive effect on the cardiovascular fitness variables of Cooper Test predicted VO$_2$ max, PWC 170 predicted workload and body image of mildly mentally retarded adults.

2.13.5 Relationship among Cardiorespiratory Fitness, Physiological Parameters and Run and Walk Tests

i. According to Cureton (1976) body fatness and 50-yard dash time were the most important determinants of the 600-yard run and mile run; VO$_2$ max (ml/min.kg) and body fatness were the primary determinants, similar in importance, of the treadmill run and treadmill walk. It was concluded that determinants of running and walking endurance performance in elementary-school-age children are multivariate in nature and cannot be interpreted as only, or even predominantly, a reflection of cardiovascular-respiratory capacity.

ii. Based upon the findings of his study, Fothergill (1976) concluded: 1. there is a significant relationship between fitness and the heart beats accumulated by college men. 2. Though fitness levels and heart beats accumulations are significantly related through broad ranges of work intensity, the relationship is not great enough to accept accumulated heart beats as a practical indicator of cardiovascular fitness. 3. Sufficiently high relationships between fitness and heart beat accumulations appear only after two to four minutes of continuous exercise at jogging speeds. 4. Low-fit subjects cannot maintain a submaximal level of effort while performing at work intensities severe enough to produce very dependable relationships between fitness and accumulated heart beat scores. 5. The use of accumulated heart beat scores by coaches and teachers to measure fitness levels has limited application.

iii. Based on the results obtained from the study, Takacs (1976) offered the following conclusions: (1) heart rate responses to running are not proportional to the distance run. However, heart rate responses for all children are greatest in the longer runs and lesser in the shorter runs; (2) response to running is near maximal after 30 seconds of running, regardless of the distance covered; (3)
Chapter-2  Review of the Related Literature

runs in excess of 200 yards produce near maximal heart rates, regardless of age and running distance; (4) heart rate response to running is not directly related to age, however, age could be used as a means for general classification in determining heart rate responses to running; (5) all children, regardless of their physical fitness level, produce maximal efforts in runs of all lengths as determined by their heart rate responses; (6) recovery after running is nearly complete after 1 minute and 30 seconds of recovery; (7) younger children tend to have a slower recovery to running, especially in longer distance runs; and (8) heart rates tend to be lower after 4 minutes of recovery than they are prior to the administration of tests where equipment is being used.

iv. Foster (1977) concluded that cross-sectional variations in distance running performance were primarily attributed to differences in VO$_2$ max and that other factors including muscle fiber composition, training volume and sprint speed might act to attenuate the VO$_2$ max-performance relationship. The findings suggest that muscle enzyme activity was not related to cross sectional differences in performance, taken as evidence of the need for longitudinal studies of running performance.

v. Dunn (1973) in his study made the following conclusions: (a) The four running performance tests i.e. 600, 900, 1200 and 1600 yards are equally, but not highly related to maximal oxygen intake: however, they are at present the best single measure of the cardiovascular fitness of fifth and sixth grade children available. (b) The 1600 yard run-walk is a reliable test. (c) The boys running times and maximal oxygen intake values were better than the girls: however, no real differences were found between grades.

vi. On the basis of the experimental results Frank Irwin (1970) concluded that individual differences in endurance capacity are only moderately related to individual differences in endurance in VO$_2$ max, the common variance being 61 percent. VO$_2$ max does not effectively predict endurance performance unless the performance is continued for at least 7 or 8 minutes under the conditions of the present experiment. With a 12 minute test the validity is 96 percent of the asymptotic value, suggesting little further gain can be expected.
beyond 12 minutes. Body weight is substantially independent and uncorrelated with heavy work endurance or with VO\textsubscript{2} max.

vii. According to Mota et al. (2006) overweight and obese children presented higher sums of skinfolds and weight compared with their lean counterparts. Increased BMI was significantly associated with lower Cardiorespiratory fitness (CRF) in girls. Thus, data clearly showed potential gender differences of body composition in CRF, which would be of great clinical significance. Therefore, even at young ages, at least for girls, the beneficial impact of low BMI values on CRF is shown with important clinical and public health implications.

2.13.6 Different Physiological Variables as Independent Variables and VO\textsubscript{2} Max as Dependent Variable

i. The study by Rivera et al. (1989) examined the hemodynamic factors associated with the lower maximal O\textsubscript{2} consumption (VO\textsubscript{2} max) in older formerly elite distance runners and concluded that VO\textsubscript{2} max is lower in master runners because of a diminished capacity to deliver and extract O\textsubscript{2} during exercise.

ii. The purpose of the study conducted by Hunter, Demment and Miller (1987) was to determine what effects a maintenance aerobic endurance training program has on strength development during a strength training program. Results indicate that the group that began aerobic and strength training simultaneously were at a disadvantage in development of strength.

iii. In the investigation by Prud, Homme, Bouchard, Leblanc, Landry and Fontaine (1984) results suggested that there were considerable individual differences in the adaptive capacity to short term endurance training. Moreover, sensitivity of maximal aerobic power to such training is largely genotype dependent.

iv. Atomi et al. (1978) found that after training, VO\textsubscript{2} max was increased, the intensity was the most effective factor among two factors viz. training intensity and frequency, to increase the aerobic work capacity.
v. Metz and Alexander (1970) investigated and found the correlations between relative VO$_2$ max and pull-ups 0.58 (from 12 to 13 years) and 0.52 (from 14 to 15 years) respectively, for bar dips, the respective correlations were 0.40 (from 12 to 13 years) and 0.46 (from 14 to 15 years). A multiple correlation of 0.739 was obtained with pull-ups and the 50 yard dash as independent variables.

vi. Berry, Storsteen and Woodard (1993) examined the effects of body mass on VO$_2$ max and efficiency. The results demonstrated that the body mass of an individual will significantly affect the determination of bicycle ergometer exercise VO$_2$ max and the calculation of gross and net efficiency. Data suggest that body mass should be considered when estimating the oxygen uptake during bicycle ergometer exercise.

2.13.7 Reviews on Run/Walk Test as an Item in Fitness Test Battery

i. Data analysis of Hsien (1995) indicated: (1) Male students did not differ among ages for skinfold thickness. (2) Younger female students (7 to 10 years old) did not differ from older female students (16 to 18 years old) in skinfold thickness. (3) Older (16 to 18 years old) and younger (7 to 10 years old) students tended to be different in the sit-and-reach test. (4) Male students performed the higher in sit-and reach test after age 10. (5) Male students above age 10 scored higher in the pull-up test than all female groups. (6) Male students above age 13 did not differ on the modified pull-up test. (7) Male students above age 13 did score better than all groups of female students in the one-mile walk/run test.

ii. Cobb (1972) developed two test batteries from the factor analysis variance of test items purported six of the eight hypothesized components of motor fitness variables. Batteries included muscular strength, muscular endurance, cardiovascular endurance, agility, power and balance. The first battery of test included tests which loaded highest on each factor: Clarke’s strength composite, McCloy’s endurance leg extension and flexion, Well’s sit-and-reach, dodging run, Bass stick balance, and vertical jump. The second test battery testing item was substituted on two factors, thus enabling the group of test battery which could be given in a shorter time, and computation of a
composite score and a ratio. Trunk flexion was substituted for Clarke’s Strength composite, and the 300-yard run with McCloy’s endurance ratio. The findings of this study substantiated the inclusion of muscular strength, cardiovascular endurance, flexibility, agility, balance, and power components of motor fitness.

iii. Singh and Singh (2008) concluded that level of cardio-respiratory function and abdominal muscular strength endurance varied among 17 and 18 years rural and urban senior secondary school boys. Rural school boys were superior in cardio-respiratory functions than their urban counterparts. However, 18 years urban school boys exhibited greater abdominal muscular strength endurance as compared to their rural counterparts.

iv. Morgan (1987) revealed significant results for three experimental groups in the 9 minute run and one experimental group in the sit-ups test. No significance was revealed between the 5 and 10 minute program or between the second and fifth grade control group in all three tests. No significance was revealed between the 5 and 10 minute program or between the second and fifth grade groups. The 0.05 level was utilized to determine significance.

v. Ghanima (1987) found that the subjects who participated in the exercise and rope jump program scores significantly better in all four components than subjects who participate in regular physical education class. They did not score significantly higher in any of the four components.

vi. Julio Morals (1993) predicted aerobic endurance and concluded that exposure to these factors appears to reach optimal levels, which differ depending the students grade level.

vii. Curb et. al., (2006) concluded that many performance tests used today are not reliable. Only a few discriminate between the most highly functioning individuals and individuals with good function. Thus, a new recommended battery included unassisted single-leg stand, balance platform “foam pad, eyes closed,” elbow flexion and knee extension strength (strength chair), grip strength, timed chair stands and the 6-minute walk. These simple performance-based tests have good reliability and discrimination across the
range of function and can be used in most clinical and research settings to quickly assess global functional level.

### 2.13.8 Reliability and Validity of Ratings of Perceived Exertion

i. D. Alison Egan (2003) concluded that the session RPE method is a valid and reliable method of quantifying resistance exercise.

ii. The findings of Lamb, Eston and Corns (1999) question the test-retest reliability of the RPE scale when used to monitor subjective estimates of exercise.

iii. According to Buckley, Eston and Sim (2000) a Braille RPE scale can be used by healthy blind people during cycle ergometry, with similar effect to the visual analogue scale recommended for use in healthy sighted people.

iv. According to Buckley, Sim, Eston, Hession and Fox (2004) the RPE and %HR max (actual) correlation with a second trial. At all Chester Step Test (CST) stages in trial 2 RPE and %HR max coefficients were significant with the highest correlations at CST stages III \( (r=0.78) \) and IV \( (r=0.84) \). CST VO\(_2\) max prediction validity is questioned but the CST is reliable on a test-retest basis. The HR/ RPE relation at >50% VO\(_2\) max reliability represents the recommended intensity for developing cardio-respiratory fitness, but only when a practice trial of the CST is first performed.

### 2.13.9 Rating of Perceived Exertion and Exercise Heart Rate

i. In the study conducted by Takeshi Ueda and Takashi Kurokawa (1991) the individual relationships between heart rate and VO\(_2\), and percentage maximal oxygen consumption (% VO\(_2\) max), were linear with a high correlation ranged \( r = 0.962 \) to 0.996 and \( r = 0.962 \)– to 0.996, respectively. Therefore, it was concluded that heart rate was valid as an index of the exercise intensity of children while swimming. Compared to the results found in adults using a similar protocol, the children's heart rate were 8.3–26.9 beats· min\(^{-1}\) higher than those of the adults at the given % VO\(_2\) max. The study showed two different patterns in the relationship between VO\(_2\) and RPE in individuals. In two subjects the RPE increased linearly with VO\(_2\) while in the other four
subjects the increase was discontinuous. If heart rate and RPE were to be applied to the setting and evaluation of exercise intensity during swimming, it would seem that Heart rate would be a more useful guide than RPE for some children.

ii. The data of Patton, Morgan and Vogel (1977) suggested that the perception of the intensity of absolute work does not differ in groups differing in their level of fitness when studied cross-sectionally. However, significant reductions in perceived exertion occur following physical training.

iii. According to Karavatas and Tavakol (2005) the correlation between RPE and HR was not as strong as previously reported, and that gender influenced the correlation. Also, RPE may be safely used to assess the exercise intensity in healthy subjects.

iv. According to Perry et. al., (2001) the mean slope coefficients for the HR and RPE Versus time relationships indicated that the physical working capacity at the heart rate threshold (PWC_{HRT}) test overestimated the maximal power output associated with steady-state HR and RPE responses. The mean HR slope coefficient suggested, that the PWC_{HRT} could be maintained for over 4 hours.

v. The findings of Dunbar et. al., (1992) indicated that target RPE estimated during a cycle ergometer graded exercise test is more accurate for regulating exercise intensity than when the target RPE is estimated during a treadmill test. The lower accuracy found for treadmill production at the higher exercise intensity may have been caused by the use of a test protocol during the estimation trial that included relatively slow speeds and large inclines. In general, RPE provide a physiologically valid method of regulating exercise intensity.
2.13.10 Relationship between Running / Walking and Ratings of Perceived Exertion

i. According to Berry, Weyrich, Robergs, Krause and Ingalls (1987) there were significant differences ($P<0.05$) when comparing local, central and overall RPEs during both the walk and run trials for the low fit group with local RPEs being significantly greater than both central and overall RPEs. There was no significant difference ($P>0.05$) between central and overall RPEs in either the walk or run trial for the low fit group. No significant differences ($P>0.05$) were found between the central, local and overall RPEs for either the walk or run trial with the high fit group. Based on the above results, it appears as if walking is perceptually more stressful than running at similar exercise intensities for high fit individuals. Since ventilation was greater for the run trial versus the walk trial for the high fit subjects, yet RPEs were lower, it does not appear as if $V_E$ provides a central signal for the determination of RPEs.

ii. According to Grant et. al., (2002) %peak VO$_2$, % HR max, and RPE were significantly higher for aerobic dance than for walking. However, both the aerobic dance and walking sessions were of adequate intensity to improve aerobic fitness in most subjects.

iii. The study of Katsanos and Moffatt (2005) provided absolute reliability estimates for heart rate responses when using RPE in a production format and suggests there may be RPE (and mode) specific practice requirements for achieving a reliable heart rate response at a given RPE.

iv. According to Erica Clarkson et. al., (1997) analysis revealed curvilinear relationships between oxygen consumption and speeds of 0.96, 1.20, 1.43, 1.67, and 1.91 m/sec. as well as between heart rate and speed. With these results, clinicians may prescribe specific speeds of backward walking for women to elicit a desired cardiopulmonary response.

v. Kavita (2009) concluded that rating of perceived exertion (RPE) was related to heart rate, volume of exercise, and intensity of exercise of male kabaddi players.
vi. Singh (2009) concluded that ratings of perceived exertion (RPE) were related to heart rate, volume of exercise, and intensity of exercise of female judo players.

vii. Pathak (2009) concluded that the intensity remained same throughout the 12 minutes run/walk test except last 200 meters. The heart rate in early distances correlated to the volume of exercise, the RPE strongly related to volume of exercise.

2.13.11 Other Related Studies

i. Leugh and Montgomery concluded that 12 minute Stationary Cycle Ergometer Test (MSCET) can be accurate in estimation of VO$_2$ max, not only with a universal working of 2.5kp for use with normal aged males.

ii. Ritchie et. al., (2005) concluded that the lower body strength and cardiovascular function tests were appropriate for use in field settings with mid-aged and young old adults.

iii. Benton and Alexander (2009) validated functional fitness tests as surrogated for strength measurements in frail, older adults with chronic obstructive pulmonary disease. From the findings they concluded that only the arm curl and chair stand tests were valid surrogates. Although multiple field tests to measure strength in a clinical settings may be desirable, these data support limiting functional testing to the arm curl for upper-body and the chair stand for lower-body strength assessment.

iv. From the three studies conducted by Willmore (1995) the findings are as follows: (1) The submaximal cardiovascular responses in young boys and girls were essentially the same, and exercise modality did not affect this comparison. (2) There were significant differences in submaximal cardiovascular responses between boys versus men and girls versus women. Furthermore, this difference was present in both the treadmill and cycle ergometer. (3) At a given rate of oxygen consumption there were no significant differences in submaximal cardiovascular responses to exercise between the treadmill and cycle ergometer in adults with only minor differences in young children.
v. Stanley concluded that unlike 12 minute run and walk test, the 12-minute swim test does not have acceptable validity and test of maximal aerobic power to young male recreational swimming.

vi. Huse et. al., concluded that the Cooper 12-minute swimming test is only moderately reliable after two practice swims and does not appear to be a valid field test of aerobic capacity in high school male swimmers ages 13 to 17.

2.14 Essence of Reviews

1. Twelve minute run and walk test is a reliable and valid indicator of cardiovascular fitness for all whether it is a junior high school boy, adolescents, middle age, old, sedentary individual, beginner runner, intermediate runner, advanced runner, overweight, asthma patient or patient with chronic diseases.

2. Determinants of running and walking endurance performance in elementary school-age children are multivariate in nature and cannot be interpreted as only, or even predominantly, a reflection of cardiovascular-respiratory capacity.

3. Reliability coefficient between Cooper’s 12 minute run and walk test ranges from 0.89 to 0.94.

4. Correlation between Cooper’s 12 minute run and walk test and 12 minute treadmill run and walk test is 0.92.

5. Correlation between Cooper’s 12 minute run and walk test and 6 minute run and walk test is 0.85.

6. Correlation between Cooper’s 12 minute run and walk test and multistage progressive shuttle test is 0.86.

7. Correlation between Cooper’s 12 minute run and walk test and submaximal cycle ergometer test is 0.76.

8. Cooper’s 12 minute run and walk test is more valid in respect to other run and walk tests like 600 yard test, 4 minute run and walk, 8 minute un and walk test, 9 minute run and walk test, 1 kilometer run and walk test, two kilometer
run and walk test, half mile run and walk test, one mile run and walk test and
20 meter shuttle run and walk test.

9. The four running performance tests i.e. 600, 900, 1200 and 1600 yards are
equally, but not highly related to maximal oxygen intake. The 1600 yard run-
walk test found to be highly reliable and valid test.

10. 1000 meters run and walk test is a reliable and valid test to measure cardio-
respiratory fitness.

11. One mile run and walk test is a valid test to estimate cardio-respiratory fitness.

12. Both the Rockport one mile walk and a nonexercise estimation of VO$_2$ max
test are comparable to the Queen’s College Step Test as valid and reliable field
measures of aerobic fitness and are good alternatives to step testing among
sedentary individuals.

13. 20 meter shuttle run test is valid test to estimate cardio-respiratory fitness.

14. Five kilometer cycle ergometer ride is a valid and reliable predictor of VO$_2$
max ($r= -0.83$).

15. Two kilometer walk test is a reasonably valid test to estimate VO$_2$ max for
moderately fit men and women, but less valid for very fit individuals.

16. Six minute walk test is a reliable and valid functional test for assessing
exercise tolerance and endurance.

17. The boys running times and maximal oxygen intake values are better than the
girls.

18. The over-ground walking test, when administered on a treadmill, is a valid
method of predictive VO$_2$ peak but under predicts VO$_2$ peak of subjects with
observed high VO$_2$ peak values.

19. Cooper’s 12 minute run and walk test is valid method for the assessment of
VO$_2$ max.

20. Correlation between Cooper’s 12 minute run and walk test and relative VO$_2$
max ranges from 0.55 to 0.90.

21. Correlation between 600 yard run and walk test and relative VO$_2$ max is 0.62.

22. Correlation between 4 minute run and walk test and relative VO$_2$ max is 0.86.

23. Correlation between 6 minute run and walk test and relative VO$_2$ max is 0.56.

24. Correlation between 8 minute run and walk test and relative VO$_2$ max is 0.87.
25. Correlation between one kilometer run and walk test and relative VO\textsubscript{2} max is 0.64.
26. Correlation between two kilometer run and walk test and relative VO\textsubscript{2} max is 0.64.
27. Correlation between half mile run and walk test and relative VO\textsubscript{2} max is 0.60.
28. Correlation between one mile run and walk test and relative VO\textsubscript{2} max ranges from 0.59 to 0.64.
29. Correlation between Cooper’s 12 minute run and walk test and 6 minute run and walk test is 0.85.
30. Correlation between Cooper’s 12 minute run and walk test and 12 minute treadmill run and walk test is 0.92.
31. Correlation between Cooper’s 12 minute run and walk test and multistage progressive shuttle test is 0.86.
32. Correlation between Cooper’s 12 minute run and walk test and submaximal cycle ergometer test is 0.76.
33. 12 Minute Stationary Cycle Ergometer Test (MSCET) is accurate in estimation of VO\textsubscript{2} max but not only with a universal working of 2.5 kp for use with normal aged males.
34. The correlations between relative VO\textsubscript{2} max and pull-ups are 0.58 and 0.52 for 12-13 and 14-15 years age groups respectively and for bar dips, the respective correlations are 0.40 and 0.46.
35. The submaximal cardiovascular responses in young boys and girls are essentially the same and exercise modality did not affect this comparison.
36. There are significant differences in submaximal cardiovascular responses between boys versus men and girls versus women.
37. At a given rate of oxygen consumption there are no significant differences in submaximal cardiovascular responses to exercise between the treadmill and cycle ergometer in adults with only minor differences in young children.
38. Individual differences in endurance capacity are only moderately related to individual differences in endurance in VO\textsubscript{2} max, the common variance being 61 percent.
39. VO$_2$ max is lower in master runners because of a diminished capacity to deliver and extract O$_2$ during exercise.

40. VO$_2$ max does not effectively predict endurance performance unless the performance is continued for at least 7 or 8 minutes.

41. After training, VO$_2$ max is increased, the intensity is the most effective factor among two factors viz. training intensity and frequency, to increase the aerobic work capacity.

42. Physical performance as measured by field test cannot be explained or reproduced by laboratory measurements. The correlation coefficient ($r^2$) for the variation between the different field and laboratory tests proved that different running tests are comparative.

43. A submaximal one mile track jog can accurately predict VO$_2$ max and is a viable alternative to maximal performance test such as 1.5 mile run.

44. The best subset variables for predicting VO$_2$ max are body weight, 600 yard run test and 12 minute run and walk test.

45. Body weight is substantially independent and uncorrelated with heavy work endurance or with VO$_2$ max.

46. The body mass of an individual will significantly affect the determination of bicycle ergometer exercise VO$_2$ max and the calculation of gross and net efficiency. Data suggest that body mass should be considered when estimating the oxygen uptake during bicycle ergometer exercise.

47. VO$_2$ max is associated with a combination of low level of infrequent participation in brisk exercise and increased BMI.

48. Aerobic training has little or no effect on cardiovascular endurance in elementary school children.

49. An eight week structured walk-jogging program has a positive effect on the cardiovascular fitness variables as predicted/estimated by Cooper’s test predicted VO$_2$ max, PWC 170 bicycle ergometer test, predicted workload and body image of mildly mentally retarded adults.

50. There are potential gender differences of body composition and cardiorespiratory fitness (CRF), which would be of great clinical significance. Therefore, even at a young age, at least for girls, the beneficial impact of low
BMI values on CRF is shown with important clinical and public health implications.

51. Rural school boys are superior in cardio-respiratory functions than their urban counterparts. However, urban school boys exhibited greater abdominal muscular strength endurance as compared to their rural counterparts.

52. Subjects who participate in the exercise and rope jump program scores significantly better in all four components viz. the one-mile jog/walk, body composition, sit-ups and flexibility test, than subjects who participated in regular physical education classes and did not score significantly higher in any of the four components.

53. Mostly test batteries used to assess cardio-respiratory fitness and general fitness includes different run and walk tests as an item.

54. There is a significant relationship between fitness and the heart beats accumulated by college men.

55. Though fitness levels and heart beats accumulations are significantly related through broad ranges of work intensity, the relationship is not great enough to accept accumulated heart beats as a practical indicator of cardiovascular fitness.

56. Heart rate is valid as an index of the exercise intensity of children while swimming.

57. Sufficiently high relationships between fitness and heart beat accumulations appear only after two to four minutes of continuous exercise at jogging speeds.

58. Low-fit subjects cannot maintain a submaximal level of effort while performing at work intensities severe enough to produce very dependable relationships between fitness and accumulated heart beat scores.

59. The use of accumulated heart beat scores by coaches and teachers to measure fitness levels has limited application.

60. Heart rate responses to running are not proportional to the distance run. However, heart rate responses for all children are greatest in the longer runs and lesser in the shorter runs.

61. Runs in excess of 200 yards produce near maximal heart rates, regardless of age and running distance.
62. Heart rate response to running is not directly related to age; however, age could be used as a means for general classification in determining heart rate responses to running.

63. All children, regardless of their physical fitness level, produce maximal efforts in runs of all lengths as determined by their heart rate responses.

64. Recovery after running is nearly complete after 1 minute and 30 seconds of recovery (alacate phase).

65. Younger children tend to have a slower recovery to running, especially in longer distance runs.

66. Heart rates tend to be lower after 4 minutes of recovery than they are prior to the administration of tests where equipment is being used.

67. Cross-sectional variations in distance running performance are primarily attributed to differences in VO\(_2\)\(_{\text{max}}\) and other factors including muscle fiber composition, training volume and sprint speed might act to attenuate the VO\(_2\)\(_{\text{max}}\) – performance relationship.

68. The individual relationship between Heart rate and VO\(_2\) and percentage maximal oxygen consumption (\%VO\(_2\)\(_{\text{max}}\)), are linear with a high correlation \(r = 0.962-0.966\) and \(r = 0.962-0.996\), respectively.

69. Ratings of perceived exertion are a valid and reliable method of quantifying resistance exercise.

70. The findings of Lamb, Eston and Corns (1999) question the test-retest reliability of the RPE scale when used to monitor subjective estimates of exercise.

71. Braille RPE scale can be used by healthy blind people during cycle ergometry, with similar effect to the visual analogue scale recommended for use in healthy sighted people.

72. If heart rate and RPE were to be applied to the settings and evaluation of exercise intensity during swimming, it would seem that heart rate would be a more useful guide than RPE for some children.

73. The mean slope coefficients for the heart rate and RPE versus time relationships indicated that the physical working capacity at the heart rate
threshold (PWC_{HRT}) test overestimated the maximal power output associated with steady-state HR and RPE responses.

74. The perception of the intensity of absolute work does not differ in groups differing in their level of fitness when studied cross-sectionally. However, significant reductions in perceived exertion occur following physical training.

75. The correlation between RPE and HR is not as strong as previously reported and gender influence the correlation. Also, RPE may be safely used to assess the exercise intensity in healthy subjects.

76. Target RPE estimated during a cycle ergometer graded exercise test is more accurate for regulating exercise intensity than when the target RPE is estimated during a treadmill test. The lower accuracy found for treadmill production at the higher exercise intensity may have been caused relatively due to slow speeds and large inclines. In general, RPE provides a physiologically valid method of regulating exercise intensity.

77. Perceptually walking is more stressful than running at similar exercise intensities for high fit individuals.

78. % VO_{2} max, % HR max and RPE are significantly higher for aerobic dance than for walking.

79. There is RPE specific practice requirements for achieving a reliable heart rate response at a given RPE.

80. The lower body strength and cardiovascular function tests are appropriate for use in field settings with mid-aged and young-old adults.

81. Unlike the 12 minute run and walk test, the 12 minute swim test does not have acceptable validity and test of maximal aerobic power in young male recreational swimming.

82. The Cooper 12 minute swimming test is only moderately reliable after 2 practice swims and does not appear to be a valid field test of aerobic capacity in high school male swimmers ages 13 to 17.

83. The reviews have documented a tremendous research gap as no research reported in regard to run and walk test validation across the age from 13 to above 60 years, specifically for the Indian population. Hence, the justification of research scholar is well validated as a source of motivation to conduct a
study to examine the validity of Cooper’s twelve minute run and walk test. Hence, the research scholar conducted a study entitled as “A Study on the Validation of Cooper’s Twelve Minute Run and Walk Test for Selected Male Populations of NCT-Delhi” to meet the well defined research objectives.

84. The review of the literature has given sound background and materials to meet the purpose of the study under the delimitations of the study to test the hypothesis. The review of literature has given the sound basis to design the research, selection of subjects, selection of variables, administration and collection of data, analysis of data as well as interpretation of the findings for valid conclusions and recommendations.