A STUDY ON ESTIMATING VO$_2$MAX FROM DIFFERENT TECHNIQUES IN FIELD SITUATION

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Abstract

The study deals with a simple technique for determining of VO$_2$max as an alternative of direct method using heart rate (HR) after step-up test. The study was conducted on 60 university athletes of India, who participated in the Indian University Athletic championships. These subjects were tested on One mile run walk test, 3 Minute step up test and Peak flow meter. After one-mile run/walk test their timing was noted and 30 seconds pulse rate was recorded immediately after the test. Immediately after completing the 3-minute step up test their 30 seconds pulse was also recorded. Further their performance was noted on peak flow meter in Liter/minute. VO$_2$max was computed by one mile run/walk test using the formula developed by Brat (Kline et al. 1987).

It was found that heart rate performance after three minute step up test was significantly correlated with VO$_2$max at .01 level whereas peak flow performance was insignificantly correlated with VO$_2$max. A regression line was developed for estimating VO$_2$max from the pulse rate obtained after three-minute step up test. Standard error of estimate was 1.81. This suggests that VO$_2$max could be estimated with greater efficiency in the field environment with the help of three minute step up test.

Key words: One-mile run/walk, Three minute Step-Up test, Peak Flow meter, Oxygen Consumption, Heart Rate, Regression line

Introduction

Maximum Oxygen intake Capacity (VO$_2$max) is the amount of oxygen we can breathe in one minute while working at full capacity. It’s a measure of fitness expressed in milliliters per kilogram per minute. Running efficiency is improved with improvement in VO$_2$max. Higher value of VO$_2$max allows you to maintain your running speed for a long time (Katch.F.I., et.al. 1973). This oxygen utilization capacity could be improved by running 80 and 100 percent of VO$_2$max. Work physiologists believe training at 95 % VO$_2$max brings the best results. They recommend that the training with higher level (100 - 95 %) VO2 max should be done for 3-5 minutes' duration (Hill et al. 1997), repeated many times in one session, with a short recovery; and the lower level (90 - 80 %) VO2 max should be for 10-20 minutes, also with short recoveries (Billat et.al., 1994).

In the research laboratory VO$_2$max is measured at a treadmill speed of 11.3 kilometers per hour(Maksud et al., 1976; Kasch, et.al. 1966; Cooper, 1968). It is therefore difficult to compute VO$_2$max in a field situation(Das et. al., 1996) and (Granato et. al., 2004) worked towards indirect estimation of VO$_2$max as an alternative of direct method. Present study is an effort to investigate the alternative method of computing VO$_2$max in the field situation through step up test (Ardle et al., 1991) and peak flow meter performance. It was hypothesized that pulse rate obtained through three minutes
Step Up test (Ardle et al., 1972) and peak flow rate of an individual would be significantly correlated with VO$_2$max obtained from One-mile run/walk test (Kline et al., 1987; Hagberg et al., 1978). In a situation if such correlations are significant, accuracy could be ensured in predicting VO$_2$max from the Step Up test or Peak flow test.

Methods

The study was conducted on the athletes of Lakshmibai National Institute of Physical Education, which is the deemed university at Gwalior, India. Sixty athletes were selected from the Institute who has either represented university or state championships in athletics. Since this is the only university of physical education in India we have the students from all over the country. Samples were selected in a stratified manner. The students were divided on the basis of four regions in India i.e North, South, East and West. From each of these strata 15 subjects were selected in a random manner.

These subjects were briefed about the concept of the study and were properly motivated to give their best performance. They were given enough trials on each of the tests i.e One mile run/walk test, Three minute step up test and Peak flow meter. Administering of these tests was done as follows;

**One Mile run/walk test:** After one-day practice six subjects were asked to run in their lanes properly marked for One mile in the track. Before testing them sufficient warming up exercise was given. For each of the subject there was a separate tester who took the timing to the nearest 1/10 of the second. Immediately after the run is complete their timing was recorded and each tester took their 15 seconds pulse.

**Three Minute Step-Up test:** For testing the subjects on three-minute step up test a bench of 16¼ inches was used. Enough practice was given for stepping up and down from the step before they finally tested. Each step had four beats: up-up-down-down. Subjects performed the test with the metronome set with a rate of 96 beats per minute, or 24 steps per minute. Immediately after the test was over for three minutes, 15 seconds pulse was recorded for each of the subjects.

**Peak Flow meter test:** Peak flow meter was used to measure the peak flow rate of an athlete to assess his lungs capacity. Subject was supposed to blow the instrument to the best possible capacity. Best out of three attempts was recorded as the final score. It gives a number (litres per minute) that tells you how fast you can blow out air after a maximum inhalation. It reveals how well lungs are working.

Reliability of the test

Reliability of all the tests were establishing using test retest methods and computing correlation coefficients between these data. For all the variables correlation coefficients were more than 0.94. This shows sufficient reliability of using these tests of measuring cardio respiratory endurance.
Statistical Analysis

After this, the scores on these three tests were obtained. VO₂max was computed from One mile run/walk test data by using the formula given by (Kline et al, 1987). Descriptive statistics were computed for all the variables. Further a correlation matrix was developed among the variables i.e VO₂max obtained from One mile run/walk test, pulse rate obtained from step up test and Peak flow capacity of all the subjects. After computing the correlation matrix a regression equation was developed for estimating VO₂max from other parameters.

Results

Descriptive statistics like mean, standard deviation, lowest and highest score and coefficient of variation were computed for all the variables. These statistics are shown in Table 1.

Table 1. Descriptive Statistics for the Different Parameters

<table>
<thead>
<tr>
<th></th>
<th>X₁</th>
<th>X₂</th>
<th>X₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>72.54</td>
<td>178</td>
<td>606</td>
</tr>
<tr>
<td>SD</td>
<td>2.53</td>
<td>7.53</td>
<td>63</td>
</tr>
<tr>
<td>Lowest</td>
<td>68.45</td>
<td>158</td>
<td>500</td>
</tr>
<tr>
<td>Highest</td>
<td>77.20</td>
<td>192</td>
<td>710</td>
</tr>
<tr>
<td>CV</td>
<td>3.49</td>
<td>4.2</td>
<td>10.4</td>
</tr>
</tbody>
</table>

X₁: VO₂ max. (Estimated from One Mile Run/Walk test)
X₂: Pulse rate (Three Minute Step Up test)
X₃: Peak flow rate in Liter/Minute (Using Peak Flow Meter)

It is evident from the above table that maximum variation occurs in peak flow rate variable. Whereas amount of variations are comparatively very low in VO₂max and pulse rate variables.

The correlation matrix developed among the variables is shown in table 2. Looking to the table 2 it is clear that only correlation between VO₂max and pulse rate was significant at .01 level whereas no correlation exist between VO₂max and Peak flow rate.
Table 2. Correlation matrix among the respiratory variables

<table>
<thead>
<tr>
<th>VO2max (X₁)</th>
<th>Pulse rate (X₂)</th>
<th>Peak flow rate (X₃)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2max (X₁)</td>
<td>1</td>
<td>-0.7*</td>
</tr>
<tr>
<td>Pulse rate (X₂)</td>
<td>-0.7*</td>
<td>1</td>
</tr>
<tr>
<td>Peak flow rate (X₃)</td>
<td>0.08</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

* Significant at .01 level

It is therefore logical to conclude that peak flow meter cannot be used to estimate VO2max of an athlete. Thus only regression equation between VO2max and pulse rate was developed. Following was the regression equation obtained after analysis.

Regression Equation:

\[ \text{VO}_2\text{max} (X_1) = 114.38 - 0.24 \text{ Pulse Rate} (X_2) \]

The relationship between VO2max and pulse rate is shown graphically in Fig.1.

Figure 1. Graphical relationship between VO2 max and Pulse rate after three minute step-up

Standard Error of Estimate

Once the regression equation was developed the next question was about the accuracy of estimating. Thus the standard error of estimate of VO2max was computed to know the accuracy in estimating VO2max from the pulse rate obtained immediately after Three Minute Step Up test. It provides a measure of the scatter of the observations about regression line. A smaller value of the standard error indicates that the scatter of points
around the regression lines is small and the prediction of estimation is precise and accurate. The following formula was used to compute the standard error of estimate of VO\(\text{max}\) on the basis of Step –Up test.

\[
\sigma_{estX_1X_2} = \sigma \cdot \sqrt{(1 - r^2)} = 1.81
\]

Where 

\(X_1: VO\text{max}. \) (Estimated from One Mile Run/Walk test)

\(X_2: \) Pulse rate \ (Three Minute Step Up test)

Since standard error of estimate is 1.81 that is very low, hence we can accurately estimate VO\(\text{max}\) from pulse rate.

### Discussion

The hypothesis that the peak flow rate would be significantly correlated with VO\(\text{max}\) was rejected in the following study. It may be due to the fact that peak flow meter measures only the performance of the lungs and is unable to give any indication about the functioning of the heart. It is only when some physical activity like in step test is done heart comes into action. The more trained is the heart quick recovery of it could be seen after performing the vigorous test. On the other hand while doing the step up test heart and lungs both are into action and therefore it reveals the performance of cardiorespiratory endurance. Only due to this reason there is a negative significant correlation between the VO\(\text{max}\) and pulse rate measured after performing the step up test. Since standard error of estimate is also very low the regression equation can very well be used to estimate the VO\(\text{max}\) in the field situation with great accuracy.

### References


