Physiological Profile of High and Low Performance Squash Players: A Discriminant Approach

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Abstract: Aim of Study: The aim of this study was to find out the physiological capacities among male squash players. The first purpose of this study was to know the role of selected physiological parameters among the high and low performance squash players; and second purpose, to develop a discriminant model for classifying squash players into high or low performance groups on the basis of selected physiological parameters. Material and Methods: A total of sixty male inter-university squash players from India were selected for the study. All subjects were examined for selected physiological variables namely vital capacity (VC), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR), Peak Expiratory Flow Rate (PEFR), Positive Breath Holding Capacity (PBHC) and Negative Breath Holding Capacity (NBHC). On the basis of the performance of the teams only forty subjects were retained for the final study in such an approach that twenty squash players were from the first four teams and twenty subjects were from the last four teams. The data was analyzed with the help of discriminant analysis using the SPSS version 19.0. Results: The mean values of only three physiological variables were found significantly higher among high performance squash players in comparison with low performance players. Further, a discriminant model was prepared to classify squash players into high and low performance groups on the basis of selected physiological variables. A discriminant function ‘Z’ was developed \( Z = 0.446 + 1.451 \text{(Vital Capacity)} -0.074 \text{(Resting Heart Rate)} \). The attained discriminant model classified correctly 77.5\% of the cases in the sample. Conclusions: Vital capacity variable had the highest discriminating power among all the physiological variables. The discriminant function Z developed in the study classified the male squash players into the low performance category, if its value was negative and into the high performance category, if positive.

Key words: Physiological Variables · Discriminant Analysis and Squash

INTRODUCTION

Squash at the elite level is primarily aerobic in nature, with intermittent bursts of activity being supplied from anaerobic energy sources [1]. Elite level squash is predominantly a moderate to high-intensity aerobic activity with intermittent bursts of energy supplied by anaerobic energy sources. It is a fast paced game of skill, speed, agility and concentration. The ability to change the direction of the ball at the last instant is an important skill as it leaves the opponent off balance [2]. Other physiological characteristics, such as the ability to maintain high percentages (80–90\%) of maximum heart rate during long intermittent periods (>30-40 minutes), play a more relevant role in squash [3-4].

Physiological variables may be defined as those variables which are directly linked with the functioning of various organs and systems such as heart rate, blood pressure, vital capacity, respiratory rate and peak flow rate. Physiological adaptation occurs in response to repeated stress application. Acute environmental stress, of either external (exogenous) or internal (endogenous) origin, disturbs the internal environment. Such stresses (forcing functions) displace physiological variables from one steady state towards another, typically in an exponential fashion. For example, the heart rate and ventilatory responses to an increase in exercise intensity display an exponential rise, to ensure oxygen supply matches elevations in metabolic demand [5].

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According to Hughes, in order to develop a test protocol to monitor the specific fitness of elite racquet sports players, it is necessary to consider the nature of the game at the elite level and identify the most relevant physiological and technical variables that influence performance [6].

Literatures revealed that elite squash players have relatively high Cardiorespiratory sports specific fitness [7], world-standard squash is predominantly a high-intensity aerobic activity with great emphasize on the anaerobic energy systems and a high uncertainty in the course of match play. To improve squash results, coaches should plan training according to the characteristics of the sport. By showing the contribution of the different energy pathways and variables easily controllable during training sessions (e.g., HR, rally duration, lactate), the accurate prescription of conditioning session is improved [8]. Furthermore, in elite sport, coaches and applied sport scientists are constantly seeking and applying innovative training methods and optimal strategies in order to have their athletes achieve high performances [9].

Very few studies have been conducted on the physiological parameters in consideration to high and low performance and to find out most contributing physiological variable that helps in discriminating the high performance players from the low performance players. In order to bridges the gap, present study was conducted. The objective of this study was to make the physiological profile of male squash players. Further, objective was to compare the selected physiological variable between the high and low performance squash players and to develop criteria for classifying male squash players into high or low performance groups by using discriminant analysis on the basis of selected physiological variables.

MATERIALS AND METHODS

A total of sixty male interuniversity squash players from all India squash racket intervarsity tournament held at Lakshmibai National Institute of Physical Education, India was selected for the present study. All subjects were examined for selected physiological variables namely vital capacity (VC), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate (HR), Peak Expiratory Flow Rate (PEFR), Positive Breath Holding Capacity (PBHC) and Negative Breath Holding Capacity (NBHC). On the basis of the performance of the teams only forty subjects were retained for the final study in such an approach that twenty squash players were from the first four teams and twenty subjects were from the last four teams in their rank. Thus, in this manner the players were classified into high and low-performance groups.

Consent was taken from each subject willing to participate before the start of study. Before administering the tests, the age in completed years, height in cm and weight in kg of the sportsmen were measured and recorded. The vital capacity (VC) of the subjects was measured with the help of dry spirometer in litres/minute, systolic, diastolic blood pressure (mmHg) and heart rate (beats/minute) was measured with the help of automatic blood pressure monitor, peak expiratory flow rate was measured with the help of peak flow meter in milliliter and Positive and Negative Breath Holding Capacity was measured with the help of stop watch in seconds.

On the basis of the performance of the teams only forty subjects were retained for the final study in such an approach that twenty squash players were from the first four teams and twenty subjects were from the last four teams.

Administration of Test

Vital Capacity: Vital capacity was measured with the help of dry spirometer, the subject allowed to sat comfortably facing the spirometer and was asked to inspire as deeply as possible to fill the lungs, while keeping the nostrils closed with a nose clip and the mouthpiece held firmly between the lips after that the subject was instructed to exhale the air as much as possible with maximum effort into the spirometer. Three trials were taken of each subject at an interval of 5 minutes and the highest among the three was taken as final.

Systolic and Diastolic Blood Pressure and Heart Rate: Systolic and diastolic blood pressure and heart rate of the subjects was measured with the help of fully automatic blood pressure monitor, for that subjects were allowed to sat comfortable on the chair, then push the cuff over the left upper arm in such a manner that tube points was in the direction of the lower arm. After the cuff has been appropriately positioned the measurement begin by pressing the 0/1 button, with in a seconds measurement results were displayed over the screen of the monitor 8.
**Peak Expiratory Flow Rate:** Peak expiratory flow rate (PEFR) is a person's maximum speed of expiration, as measured with a peak flow meter, a small, hand-held device used to monitor a person's ability to breathe out air. In order to measure the peak expiratory flow rate, subjects were instructed to assure that the sliding marker or arrow on the peak flow meter was at the bottom of the numbered scale (zero or the lowest number on the scale), after that they were asked to stand up straight and took a deep breath (as deep as they can), then after subject put the mouthpiece of the peak flow meter into their mouth and closed their lips tightly around the mouthpiece to blow out as hard and as quickly as possible. The force by which the air coming out of the lungs caused the marker to move along the numbered scale was recorded in milliliter as the score of peak expiratory flow rate. Three trials were taken of each subject at an interval of 5 minutes and the highest among the three was taken as final.

**Positive and Negative Breath Holding Capacity:** Positive Breath Holding Capacity was measured during holding of the breath after full inhalation and the result was recorded in seconds. To measure the positive breath holding capacity, subjects were instructed to place the nose clip tightly. They were asked to inhale through the mouth to maximum capacity. As soon as the subjects inhaled and closed the mouth, the stopwatch was started. As soon as the subject opened the mouth to exhale, the stopwatch was stopped and the time given by stopwatch was recorded in seconds as the score of positive breath holding capacity.

Negative Breath Holding Capacity was measured during holding of the breath after full exhalation and the result was recorded in seconds. To measure the negative breath holding capacity, the subjects were instructed to place nose clip tightly. They were asked to exhale through the mouth to the maximum capacity. As soon as the subjects exhaled and closed the mouth, the stopwatch was started. As soon as the subjects opened their mouth to inhale, the stopwatch was stopped and the time given by the stopwatch was recorded as the score of negative breath holding capacity.

**RESULTS**

Firstly, the result was expressed in descriptive statistics as mean and standard deviation depicted in Table 1 and 2. Further, a comparison between high-performing and low-performing squash teams was made on selected physiological variables with the help of independent t-test. The data was also analyzed by using discriminant analysis for developing discriminant function for classifying individuals into high and low performance groups. The whole data was analyzed with the help of SPSS software package (ver. 19.0). The results so obtained are discussed in this section.

Table 1 reveals the comparison of mean values between high and low performance groups in all seven physiological variables. There was a significant difference found between high performance and low performance groups in case of vital capacity, systolic blood pressure and resting heart rate while insignificant difference was found in rest of the variables. Furthermore, it may be concluded that the mean scores of all three significant variables were significantly higher in the high performance group than in the low performance group. Thus, it may be interpreted that the cardiorespiratory adaptation was superior among the high performing squash players. This is true also because success to a great extent in the squash game depends upon the proper functioning of the cardiorespiratory system of the players.

<table>
<thead>
<tr>
<th>Variable</th>
<th>High Performer</th>
<th>Low Performer</th>
<th>Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital Capacity</td>
<td>3.59 ± .41</td>
<td>3.0950±.55</td>
<td>.50*</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>136.75±13.05</td>
<td>126.95±15.99</td>
<td>9.80*</td>
</tr>
<tr>
<td>Diastolic Blood Pressure</td>
<td>83.60±12.38</td>
<td>81.60±9.91</td>
<td>2.00</td>
</tr>
<tr>
<td>Resting Heart Rate</td>
<td>67.30±5.03</td>
<td>75.30±11.15</td>
<td>-8.00*</td>
</tr>
<tr>
<td>Positive Breath Holding Capacity</td>
<td>34.10±9.74</td>
<td>37.55±13.23</td>
<td>-3.25</td>
</tr>
<tr>
<td>Negative Breath Holding Capacity</td>
<td>21.30±6.61</td>
<td>19.35±6.40</td>
<td>1.95</td>
</tr>
<tr>
<td>Peak Flow</td>
<td>530.50±58.44</td>
<td>518.50±57.33</td>
<td>12.00</td>
</tr>
</tbody>
</table>

* Significant at 0.05 level
Table 2: Unstandardized Canonical Discriminant Function Coefficients

<table>
<thead>
<tr>
<th>Function</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital Capacity</td>
<td>1.451</td>
</tr>
<tr>
<td>Resting Heart Rate</td>
<td>-0.074</td>
</tr>
<tr>
<td>(Constant)</td>
<td>.446</td>
</tr>
</tbody>
</table>

Table 3: Wilks’ Lambda Distribution

<table>
<thead>
<tr>
<th>Test of Function(s)</th>
<th>Wilks’ Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.686</td>
<td>13.964</td>
<td>2</td>
<td>.001</td>
</tr>
</tbody>
</table>

Table 4: Classification Matrix

<table>
<thead>
<tr>
<th>Levels of Performance</th>
<th>Predicted Group Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Original Count</td>
<td>16</td>
</tr>
<tr>
<td>Original %</td>
<td>80.0</td>
</tr>
</tbody>
</table>

Table 5: Standardized Canonical Discriminant Function Coefficients

<table>
<thead>
<tr>
<th>Function</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vital Capacity</td>
<td>.716</td>
</tr>
<tr>
<td>Resting Heart Rate</td>
<td>-.643</td>
</tr>
</tbody>
</table>

Table 6: Functions at Group Centroids

<table>
<thead>
<tr>
<th>Levels of Performance</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>0.660</td>
</tr>
<tr>
<td>Low</td>
<td>-0.660</td>
</tr>
</tbody>
</table>

77.5% of original grouped cases correctly classified.

The data was further analyzed by using discriminant analysis and the obtained results are shown in Tables 2 to 6.

Table 2 shows the unstandardized canonical discriminant function coefficients. These coefficients were used to develop the discriminant function. The resulting discriminant model included only two physiological variables because these two variables were found to have a significant discriminant power. Thus, the discriminant function developed by using these discriminant coefficients was as follows:

\[ Z = 0.446 + 1.451 \text{ (Vital Capacity)} -0.074 \text{ (Resting Heart Rate)} \]

Wilks’ lambda indicates the significance of the discriminant function. Since the above table 3 reveals the value of Wilks’ lambda distribution as shown in was 0.686 and therefore the discriminant model can be considered to be good enough for developing a discriminant function. Since the value of chi-square in Table 3 was significant (p = 0.01), it may be inferred that the discrimination function developed in the model between the two groups was highly significant.

Table 4 shows classification matrix which provides the summary of correct and wrong classification of subjects in both groups on the basis of the developed discriminant model. From the above table it can be seen that the percentage of correct classification amounted to 77.5%, which is quite good and therefore it may be concluded that the discriminant model developed was efficient.

DISCUSSION

The obtained results showed that only two physiological variables namely vital capacity and resting heart rate significantly differ high from low performance male squash players. These results are in a partial consonance of the study done by Docherty [3].
Hence, one can keep in mind that physiological variables are utmost important in order to achieve excel in the performance, as supported by Lees et al. [13] according to them physiological demands in racket games are highly influenced by the fact that players have to accelerate, decelerate, change direction, move quickly, maintain balance and generate optimum stroke production repeatedly.

The Standardized Canonical Discriminant Function Coefficients revealed that vital capacity had highest discriminating power among all the physiological variables. Since, pulmonary functions play a more pertinent role in squash because this game involves fast and typical movement of the body parts continuous for a longer duration, to fulfill this demand player have to consume more oxygen to do work efficiently, this result in higher vital capacity.

Since the percentage of correct classification of cases was 77.5% hence the developed model can be considered efficient. This answered the second purpose of the study. Since the discriminant model was developed on the basis of a small sample so, the level of accuracy shown in the classification matrix may not hold for all future classifications of new cases. The findings of the present study suggest that squash performance during competition depends upon many factors, one of which is the physiological fitness.

CONCLUSIONS

On the basis of the results of the study, It might be concluded that physiological variables namely vital capacity and resting heart rate play an important role in discriminating high and low performer squash players. Within the limitations of the study, results also showed that out of all the selected physiological variables, only vital capacity had highest discriminating power. A model so developed in this study to classify the high and low performer squash player was efficient as percentage of correct classification of cases was 77.5%. Hence, one should concentrate more on these variables in order to achieve excel in the performance. The implication of these findings may helpful for coaches and exercise physiologists in order to improve upon the physiological fitness that leads to excel in their performance. Specifically, exercise physiologist could work on physiological factors along with all others factors that may help in improving the performance. One of the limitations of the present study was the small sample size restricts the generalizability and also led to the adoption of a generous alpha level. Secondly, this study was delimited to only intervarsity level squash racquet player. Thus, there is a clear need for further research to cross-validate the findings from the present study on a different and larger sample.

REFERENCES