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## Proportionality of Anthropometric and Physical Fitness Performance on Youth Aerobic Capacity Model

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### Abstract

Oxygen consumption is linked to the overall fitness performance and all the causes of the mortality and cardio-respiratory fitness is determined by the oxygen consumption. The purpose of the current study was to determine the relationship between predicted oxygen consumption towards physical fitness and anthropometric components on Malaysian youth. A total of 219 male student-athletes randomly were recruited to participate in this study with aged between 13-15 years old groups from entire state in Malaysia. Anthropometric and physical fitness battery test were conducted to the student-athletes and recorded for further analysis. To achieve an objective, Multiple Linear Regression were computed whereas  $VO_{2max}$  denoted as a determiner meanwhile others physical fitness components and anthropometrics were selected for the predictors. Even though aerobic capacity model shows weak association on anthropometrics and physical performances ( $R^2 = 0.275$ ,  $\approx 27.5\%$ ), still it proved to be a significant effect,  $p < 0.0001$ . The main contributor that effect the association is dominantly by 40m speed (40.95%), weight (23.81%), Push up (13.33%), 10m speed (9.52%) and Power/standing broad jump (5.71%). Finding summarize the proportionality of each predictors toward the importance of oxygen consumption model which suggesting the contribution each factor that enroll for the better cardio-respiratory fitness efficiency.

**Keywords:** Aerobic Capacity Model, Relative Performance, Physical Fitness Performance.

### Introduction

Anthropometric is the physical measurements of human size, shape, proportion and body composition for the purposes of comparison and establishing population norms, such as gender,

age, weight, ethnicity or race (Abdullah et al., 2016a). Anthropometric measurements are useful in many fields and it is related to the physical fitness performance. Physical fitness includes strength, endurance, agility and coordination, it is apparent that no one activity is sufficient for its full development. Supplementary exercises are required if total physical conditioning is to be achieved. Physical fitness is important from another point of view (Abdullah et al., 2016b).

A close relationship exists between physical fitness and mental and emotional fitness or morale. Fatigue, weakness, lack of stamina, and physical exhaustion are usually associated with a low state of morale. People who are physically fit are also healthier, are able to maintain their most optimum weight, and are also not prone to cardiac and other health problems. In order to maintain a relaxed state of mind, a person should be physically active. A person who is fit both physically and mentally is strong enough to face the ups and downs of life, and is not affected by drastic changes if they take place (Abdullah et al., 2016c).

$VO_{2max}$  is basically a measure of aerobic fitness. It is linked to overall fitness and all the cause mortality. According to the American College of Sports Medicine (ACSM), cardio-respiratory fitness is determined by oxygen consumption, technically called  $VO_{2max}$ . This is measured by how much oxygen (in millilitres) your body can use per kilogram of body weight per minute (Abdullah et al., 2016d).  $VO_{2max}$  is the maximum amount of oxygen the body can use, and it directly correlates to fitness capacity. An athlete with a  $VO_{2max}$  of 65 ml/kg/min will be able to perform at a high level for a longer duration than an athlete with a  $VO_{2max}$  of 40 ml/kg/min. However, this relates to aerobic work. Someone with a high  $VO_{2max}$  will not necessarily be able to perform at a higher capacity during resistance exercise or short-duration high-intensity work, such as sprints. Based on Hill's theory, high  $VO_{2max}$  values is essential to the successful of the running distance but it is limited by the ability of the cardio respiratory system to supply oxygen into specific muscles (Bassett and Howley, 2000).

While  $VO_{2max}$  seen as a measure of how efficiently the body works as a whole, some runners even see the  $VO_{2max}$  as the 'maximum potential' a person could accomplish, and they adjust their training tactics to aim towards that potential (Abdullah et al., 2017a). Although these phenomenon is an important method for training regime, proportionality contribution of the related variables might influence  $VO_{2max}$  are less been explored especially by integrating body functional capacity and anthropometric, especially. Thus, the specific objective of the study was to determine the relationship between predicted oxygen consumption towards physical fitness and anthropometric components on Malaysian youth student-athletes.

## **Materials and Methods**

### **Participants**

The participants involved in this study are male student-athletes secondary school who are active in several sports, which is athletic, silat, hockey, sepak takraw and boxing. A total of 219 male student-athletes randomly were recruited to participate in this study with aged between 13-15 years old groups drawn from entire state in Malaysia. The student-athletes currently under Talent Identification and development program (TID) for training and consequently, targeted to be promoted to state and national athletes respectively. The student-athletes, coaches as well as

stakeholders of the sport council were informed about the objective of the current research. Written approval as well as consent forms from the sports council, guidance and all the male student-athletes was obtained. All the protocol and procedures for the current study were approved by the University Human Research Ethics Committee with a reference number UniSZA/02/1/2016/Jil. 207.

### **Anthropometric Test**

Anthropometric testing include weight, height, arm span, and sitting height. Standing height was measured with a wall-mounted wooden stadiometer to the nearest 0.5 cm. Body weight was evaluated with a standardized electronic digital scale to the nearest 0.01 kg. Arm span is the physical measurement of the length from one end of an individual's arms (measured at the fingertip to the other when raised parallel to the ground at shoulder height at a 90° angle. The average reach correlated to the person's height. Sitting height measurement is conducted in addition to the standing height. Sitting height gives a measure of the length of the trunk. It is a measurement of the distance from the highest point on the head to the base sitting surface. All the measurements were executed in accordance with ISAK protocol (Marfell-Jones et al., 2012). The measurements were obtained twice, and the mean value was generated as the final score.

### **Physical Performance Test**

#### **Muscle Strength**

The test was executed according to the suggested method by prior researchers for physical fitness tests (Noguchi et al., 2013). Participants lay on their back with their knees bowed at around right edges while both feet were situated level on the floor. Participants held their hands against their chest where they should stay throughout the test. In the test process, a supporter held the participants' feet put on the ground. Participants sat up until they touched their knees to both elbows; then, they came back to the floor. The movement was frequented as many times as possible under the period for 60 s. The aide totaled and recorded the quantity of right finished sit-ups. The test was measured just once attributable to the impact of exhaustion.

#### **Speed**

As proposed by Russell and Tooley (2011), linear sprint speed was evaluated over 20 m. Starter and ending pointers were positioned for 10 m, 20 m and 40 m. Participants started the test from a standing start at a distance of 0.2 m behind the initial timing gate before starting the test taking after a countdown from the lead researcher. The participant was told to keep running at maximal velocity throughout the full length of time of the sprint test. The participant was told to keep up the maximal pace until passing the marker on which the mentor stood. The execution times were recorded respectively. Players performed two reiterations with the best (fastest) times utilized for statistical analysis.

#### **Aerobic Capacity Test**

The multistage 20-m shuttle run test developed by Leger and Gadoury (1989) was implemented to acquire the participant's maximal oxygen uptake. Every participant kept running for whatever length of time he/she could afford until could no more keep pace with the velocity of the tape. Test results for every participant were expressed as an anticipated  $VO_{2max}$  accomplished by

checking the last level and ended shuttle number at the time when the participant voluntarily resigned from the test. In spite of the fact that motivation and drills of the participants might influence their scores, it is still a legitimate test in assessing maximum oxygen uptake and can be performed in considerably a large number of participants minimizing expenses and time.

#### Flexibility

The sit and reach test are a common measure of flexibility, and specifically measures the flexibility of the lower back and hamstring muscles. This test is important as because tightness in this area is implicated in lumbar lordosis, forward pelvic tilt and lower back pain. This test was first described by Wells and Dillon (1952) and is now widely used as a general test of flexibility.

#### Upper Muscle Strength

The participants assumed a prone position on the floor with the hands directly underneath the shoulders, legs extended and together, and toes tucked under so they are in contact with the floor, (push up position). The participants then push with the arms until they are fully extended and then lower their body until their chest down towards the floor. At this point, the line from the head to the toes should be straight. All of these movements were executed only by the arms and shoulders. The score was determined by the number of push-ups while maintaining correct form. The test was also administered ones to avoid fatigue. However, for the female participants, the test was modified such that they have to cross their leg and their knees touching the floor.

#### Power

Standing broad jump were measured using tape assess distance jumped, non-slip floor for take-off, and soft-landing area preferred. The take off line should be clearly marked. The procedure is the athlete stand behind a line marked on the ground with feet slightly apart. A two take-off and landing are used with swinging of the arm and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing and both feet without falling backwards. Three attempts are allowed.

Vertical jump test was performed using a Yardstick vertical jump device (Swift Performance Equipment, NSW, Australia). Players were requested to stand with feet flat on the ground, extend their arm and hand, and mark the standing reach height. After assuming a crouch position, each participant was instructed to spring highest possible point. No specific instruction was given about the depth or speed of the counter movement (Gabbett et al., 2007). To assess lower body power a vertical jump was measured using a Takei vertical jump meter (Takei Scientific Instruments Co. Ltd Japan). The vertical jump score was the highest value recorded during three trials (Pyne et al., 2005).

#### Data Analysis

Prior to main data analysis, dataset has been tested for the missing data, data error, normality, and outlier data by employing Kolmogorov-Smirnov test and visualization analysis of box plot (Abdullah et al., 2017a). After taken into consideration by data cleaning, the total of the missing and error data was little ( $\approx 3\%$ ). Thus, nearest neighbor procedure was applied in the current study by replacing the missing and error data because of the effectiveness of the method itself.

Theoretically, this method was computed the gap between each segment of the missing data and the closest segment to it (Abdullah et al., 2017b). It's expressed as shown in the equation 1 below, whereas  $y$  is the interpolant,  $x$  is the interpolant of each segment. Meanwhile,  $y_1$  and  $x_1$  are the range of segments for starting point of the gap, and the opposite for ending segments of the gap is  $y_2$  and  $x_2$ .

$$y = y_1, \text{ if } x \leq x_1 + \frac{x_2 - x_1}{2} \text{ or; } y = y_2, \text{ if } x \leq x_1 + \frac{x_2 - x_1}{2} \quad (1)$$

Multiple linear regression was applying to examine the prediction performance of physical fitness and anthropometric predictors in explaining aerobic capacity and furthermore scrutinize the contribution of each predictors. Temporarily, assumptions test of Multivariate Data Analysis (MVA) were tested encompasses normality, linearity, and multicollinearity (Abdullah et al., 2016a). These assumptions need to be met to ensure that least square measures are unbiased (Cunningham & McCrum-Gardner, 2007). Additionally, linear regression was conducted in this study for the major test to achieve the objective. Linear regression is an approach for modeling the relationship between a scale dependent variable  $y$  and one or more explanatory variables (or independent variables) denoted  $X$  (Freedman, 2009). Linear regression models are often fitted using the least squares approach, but they also be fitted in other ways, such as by minimizing the 'lack of fit' in some other norm (as with least absolute deviations regression), or by minimizing a penalized version of the least squares loss function as in ridge regression as expresses in equation 2, 3 and 4 as denoted by  $R^2$ , root mean square ( $RMSE$ ), and the model itself.

$$R^2 = 1 - \frac{\sum(x_i - y_i)^2}{\sum y_i^2 - \frac{\sum y_i^2}{n}} \quad (2)$$

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - y_i)^2} \quad (3)$$

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_{p-1} x_{p-1} + \varepsilon \quad (4)$$

## Results

Table 1 projects the descriptive statistic for the participant on all tested variables. From the table, it can be seen that the number of participants observed ( $n = 219$ ), the minimum, the maximum, the mean as well as the standard deviation of the variable are projected.

Table 1: Descriptive Statistic of the Variables

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Predicted VO <sub>2max</sub>	219	18.300	47.700	32.984	6.188
Weight	219	26.200	68.400	43.611	8.451
Height	219	125.400	186.000	154.201	9.170
Sitting height	219	64.400	88.700	77.761	5.006
Arm span	219	123.500	187.000	156.680	10.649
Vertical jump	219	30.000	60.000	43.744	6.293
10 meters	219	1.610	2.500	2.035	0.157
20 meters	219	3.010	4.240	3.561	0.273
40 meters	219	5.050	8.010	6.607	0.565
Sit & reach	219	15.000	48.500	30.491	5.519
Max push up	219	1.000	40.000	16.927	8.472
1 min sit up	219	1.000	30.000	16.429	7.157

Table 2 shows the goodness of fit statistics for 219 samples in this study. It shows the model of the aerobic capacity are  $R^2 = 0.275$  which explained that the model has approximately accounted for the total of 28% variability of the whole data set. Therefore, it can be concluded that the model of this study shows weak justification in explaining tested predictors.

Table 2: The goodness of Fit Statistic of VO<sub>2max</sub> (ml/kg/min) Predicting the Physical Fitness Related Performance.

Observations	219.000
Sum of weights	219.000
DF	206.000
R <sup>2</sup>	0.275
Adjusted R <sup>2</sup>	0.233
MSE	29.383
RMSE	5.421

Table 3 proves that the analysis of variance between VO<sub>2max</sub> (DV) are significantly affected by all variables consist anthropometrics and physical fitness related performance (IV). The significant value achieves at  $p < 0.0001$ . The F test the effect of IV, which mean the entire variables used in the current study are significant.

Table 3: Analysis of Variance.

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	12	2293.392	191.116	6.504	< 0.0001
Error	206	6052.889	29.383		
Corrected Total	218	8346.281			

Regression analysis is an approach that is used to define the mathematical relationship between outputs. This mathematical relationship is expressed in the form of a regression model, which is used to predict the value of the output variable as a function of the value of the input variables. The multiple R value is equal to the square root of the R square value (Abdullah et al., 2016b). The multiple R is equal to the absolute value of the correlation between the dependent variable and the predictor variable (Abdullah et al., 2017b). Further analysis was carried out to identify the contribution toward aerobic capacity model by employing leave one out method as reckon by the previous researcher (Swaby et al., 2016). As a result, Figure 1 projected the contribution of each components which explained in bar graph by percentages. It can be seen that top five of the main contributor are 40m speed (40.95%), weight (23.81%), Push up (13.33%), 10m speed (9.52%) and Power/standing broad jump (5.71%).

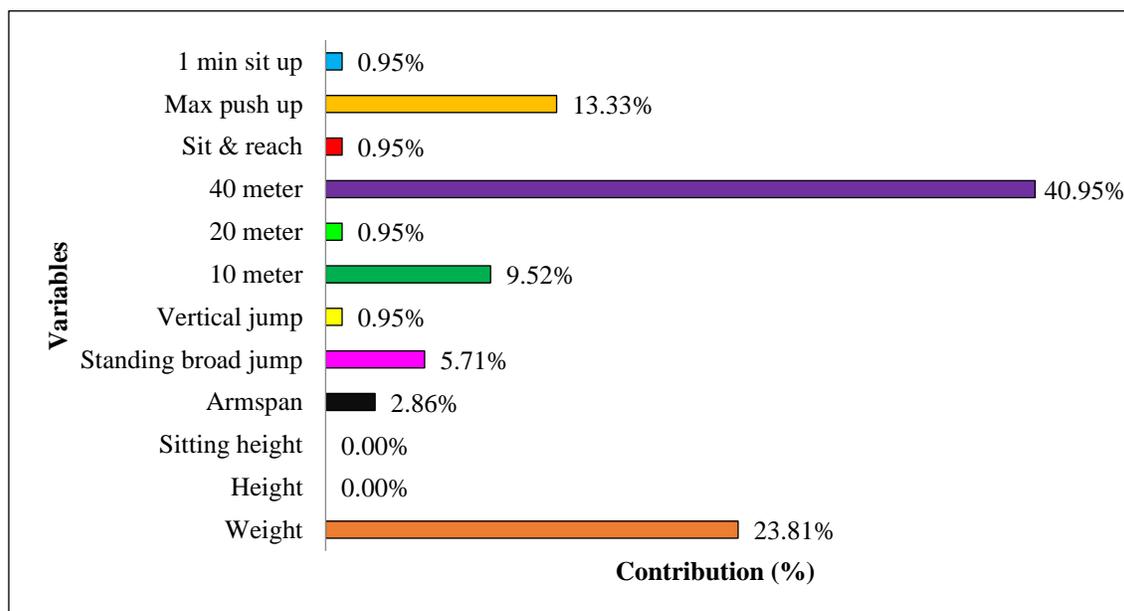


Figure1: Bar graph percentage of the contribution to the Aerobic Capacity Model.

### Discussions

The purpose of present study was to predict the relationship of physical fitness and anthropometric variables on cardiovascular endurance performance among student-athletes in secondary school. Afterward, contribution of the source of the significant factors will explained in the relative percentage (see Figure 1).

Based on the findings, fundamental factors such as anthropometric and physical fitness components elucidate significant effect on cardiovascular performance (aerobic capacity model) even though, findings from the current study suggest that these components predict weak association on aerobic capacity model (see Table 2). Based on this clarification, thus it is worth to determine the contribution of the components for filling the existing to the knowledge gap. Overall, the study found a massive contribution on speed parameters, body size (arm span and weight) and muscle endurance (max push up) and these parameters contributes up to 91.37 %

(effect on 27.5 % of aerobic capacity model). This suggesting that, all the parameters generally associated with aerobic capacity model only 27.5 % and it is significantly fragmented from major contributor mostly from speed, body size and muscle endurance. Similarly, this finding is in concordance with previous study mostly related to the rugby and soccer game which revealed that speed and physical characteristics plays an important role in the success team has during a season (Swaby et al., 2016; Helgerud et al., 2001). It is also highlighted that aerobic capacity is influenced by a greater volume of work during the rugby and soccer game (Swaby et al., 2016; Helgerud et al., 2001). Theoretically, by increasing the aerobic capacity model will lead to the healthiest life style and reduce the risk of the morbidity and mortality. Statistically, there is an evidence showing that one in three adults globally does not meet public health recommendations for physical activity (Hallal et al., 2012), and unfortunately more than one third are overweight (Ng et al., 2014).

Malina et al (2004) reported that the capability to execute continuous activity under essentially aerobic conditions depends on the ability of the cardiovascular and pulmonary systems to supply oxygenated blood to tissues and on the capacity of tissues (large skeletal muscle) to extract oxygen and oxidise substrate. The researchers explained further that the dimensions of the heart and lungs expand with age in a manner consistent with the increase in body mass and stature. The increase in the size of the heart is related to increase in stroke volume (blood pumped per beat) and cardiac output (product of stroke volume and heart rate, litres per minute). Likewise, increase in lung size (proportionate to growth in height) results in greater lung volume and ventilation despite an age-associated decline in breathing frequency. This supported the current findings that the stature of an individual could determine the cardiovascular endurance of the person which associate with the greater lung sizes resulting for the greater amount of blood flow to be supplied on the working muscles.

### **Conclusion and Recommendations**

In the current study, anthropometric (weight and arm span) and physical fitness (push up, speed from various type of distance) components predictive significantly on aerobic capacity model generally 27.5 %. The possession of cardiovascular respiratory will contribute to the development of healthy body and mind and hence enable the forces to discharge physical activity effectively. Therefore, the cardiorespiratory endurance functioning of the pulmonary and cardiovascular systems to deliver oxygen and the ability of tissues to extract oxygen from the blood for a better delivery of human performance. It might useful finding for youth and adolescent generally to keep physically fit by focusing on the factors that might influence the aerobic respiratory efficiently and reducing the risk of the morbidity and mortality. The current study serves as a pioneer for examining some related physical fitness and anthropometric with their association to the performance of cardiovascular endurance among student-athletes in the secondary school especially in Malaysia setting. However, further research is required to consider female subjects as well as investigate the association of other anthropometrics variables with cardiovascular endurance by reference to both males and females gender.

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