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Original Article

Correlation of Percentage Body Fat and Muscle Mass with Anaerobic and Aerobic Performance in Collegiate Soccer Players

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Abstract

The aim of the study was to determine the correlation of percentage body fat (%BF) and muscle mass (MM) with aerobic and anaerobic performance in collegiate soccer players. Forty eight male collegiate soccer players were recruited and all the subjects were measured for % BF and MM using bioelectrical impedance analysis (BIA) followed by anaerobic and aerobic performance. The anaerobic performance was measured using vertical jump test and 30 meter sprint test. Aerobic performance tests were Harvard step test and Cooper 12 min run/walk test. The Pearson correlation coefficient for % BF and MM with anaerobic and aerobic performance was calculated. The results revealed that %BF significantly correlated with tests of aerobic and anaerobic performance. MM also significantly correlated with anaerobic performance. However, there was no correlation with aerobic performance. The findings suggest the percentage body fat predict aerobic performance rather than the muscle mass.

Introduction

Body composition is an important component, of physical fitness and in creating athlete's profiles and conditioning programs. Body composition refers to the relative amounts of fat and fat free mass. The measurement of physical fitness components should be included in order to monitor progress and adaptation to training, as fitness is considered one of the most important markers of health (Palacios et al., 2015). However, many a times much more time is spent on increasing the physical fitness of athletes without taking into consideration of their body composition and nutritional status (Popovic et al., 2013). High body mass, whether it is due to increased body fat or decreased lean body mass affects aerobic performance. (Maciejczyk et al., 2014). Mirzaei et al (2010) compared the body composition, aerobic power, anaerobic power and strength of Iranian, free style and Greco-Roman wrestlers participating in Beijing Olympic games. The findings showed that high body fat content affected performances. Kiflu et al (2012) reported that sports performance such as speed, endurance and jumping ability are all negatively affected by a high level of relative fat in the body.

In the last decades, information about relationship between body composition and physical fitness in children and adults has been published. These studies revealed that excessive fatness has a negative impact

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on performance task as in long jump, sprint and on tasks in which body must be lifted in space (Kiflu et al., 2012). Monyeki et al (2012) noted that the consequence of both underweight and obesity are related to decreased work capacity and reduced physical fitness, cardio respiratory fitness, strength and speed of movement.

Even though there is some information available on relation of percentage body fat and muscle mass with anaerobic and aerobic performance in various athletic populations, the data on relation of percentage body fat and muscle mass with anaerobic and aerobic performance in young collegiate soccer players is limited. Therefore this study tried to determine the correlation of percentage body fat and muscle mass with aerobic and anaerobic performance in collegiate soccer players. The data of this study may provide useful information to the coaches and trainers, thus helping them to chalk out a training program that would help the athletes perform better.

Methods

Subjects

The sample size was calculated using PASS 2008 software. A sample size of 47 subjects achieves 90% power (1-β) with moderate effect size of, r = 0.45 at α=0.05. (Zar 1984). Forty eight male collegiate soccer players from Jamia Millia Islamia, New Delhi, India participated in the study. Ethical clearance was taken from institutional ethics committee of Jamia Millia Islamia, New Delhi, India. The mean (±SD) age (years), height (cm), weight (kg), BMI (kg/m^2) of the subjects were 21.06 (±2.5), 171.86 (±5.3), 62.8 (±5.2) and 21.25 (±1.5), respectively. Male soccer players with a BMI range of 18-24.9 kg/m^2 were included in the study. During the study, participants were asked to abstain from competition, and avoid the ingestion of alcohol, smoking and nutritional supplements.

Procedure

All subjects were measured for percentage body fat and muscle mass using bioelectrical impedance analysis (BIA) following which their anaerobic and aerobic performance was assessed. The anaerobic performance was measured using vertical jump test and 30 meter sprint test (time). The aerobic performance was assessed, by VO_2 peak and physical performance index (PFI) using Harvard step test and Cooper 12 min run/walk test respectively.

Subjects were tested on three separate days with at least 48 hours between testing days. Prior to each test, the subjects were given a demonstration of the tests. On the first day of testing, subjects reported to the laboratory in the health centre of Jamia Millia Islamia, New Delhi where they were measured for height, weight, body fat percentage and muscle mass. Immediately thereafter, subjects were tested for anaerobic performance using the vertical jump test and 30 m sprint. On the second day of testing, aerobic performance was assessed indirectly by Harvard step test (VO_2 peak). On the fourth day of testing, they were tested for aerobic performance by using the Cooper 12 minute run/walk test (PFI). The same therapist administered each individual test. Then the correlation between percentage body fat and muscle mass with anaerobic and aerobic performance was determined.

Measurement of Percentage Body Fat and Muscle Mass

Percentage body fat (%BF) and muscle mass were measured in the laboratory with the use of a tetra polar bioelectrical impedance analyzer (Maltron International Ltd. BioScan 916).Measurements were taken 4 hours postprandial and within 30 min after voiding. The subjects were asked to refrain from any type of exercise within 12 hours of the test and were asked to refrain from alcohol consumption within 48 hours of the test. They were not allowed to take any diuretic medication within 7 days of the test (Heyward, 2001).

Each subject clothed without shoes or socks, lied supine on a non conducting surface/couch. The position of the arms was in 30^0 of abduction and the legs were positioned at approximately 45° of abduction (Walter-Kroker et al., 2011). Two electrodes were placed on the right hand/wrist: one on the dorsal surface of the hand 1 cm proximal to the third metacarpophalangeal joint, and the other centrally on the dorsal side of the wrist in line with the ulnar head. Two electrodes were placed on the right foot/ankle: one on the dorsal surface of the foot 1 cm proximal to the second metatarsophalangeal joint, and the other centrally on the dorsal surface of the ankle between the lateral and medial malleoli. All electrodes were placed at least 5 cm apart (Pateyjohns et al., 2006). During the measurement, the instrument recorded whole body impedance from the hands to the feet by applying an alternating electric current of 0.8 mA at an operating frequency of 50 kHz. Finally, body fat percentage and muscle mass were calculated by the analyzer from the whole body impedance value and for the pre-entered personal data (age, gender, height, weight) of the corresponding subject. There is reporting of high reliability in a single trial of the BIA, indicating one trial with the BIA is sufficient (Fornetti et al, 1999).

Vertical Jump Test (Anaerobic Performance)

Vertical jump test was performed in the laboratory. Prior to the vertical jump test, the subjects performed an 8-10 minute dynamic warm-up (Changela and Bhatt, 2012). The therapist applied ink at the end of participant's finger tips. Then subjects stood against a wall, with a measuring tape fastened to a chart paper. They were asked to, reach up as high as possible with one hand while keeping both feet remaining on the ground and to mark the wall with the finger tip. This was taken as standing reach height. Then they were instructed to jump vertically (initiated from a knee flexion of 90°) and execute a maximum vertical jump while swinging the arms actively. Vertical jump height (cm) was determined calculating the difference between standing reach height and jump reach height (Daneshjoo et al., 2013). After 2-3 practice trials, 3 trials were carried out and 1-2 minutes of rest was allowed between jumps. The best trial was used for further analysis.

30 Meter Sprint Test (Anaerobic Performance)

30 m sprint test was performed outdoors. Two cones were placed at 30 m distance apart. Prior to the sprint test, all the subjects performed a thorough warm up session consisting of 10 minutes (Alemdaroglu, 2012). The starting position was standardized for all subjects. Subjects start with the left toe approximately 30 cm back from the starting line and the right toe approximately in line with the heel of the left toe. Subjects performed three 30m sprint trials with at least three minutes rest between trials (Janssen et al, 2000). Time was recorded using a digital stop watch. The fastest of the three trials was used as the criterion measure (Baker and Davies, 2004).

Cooper 12 minute run/walk test (VO_2 peak - Aerobic Performance)

The test was performed outdoors, around a measured track of 400 m marked with running lanes and cones (Kiflu et al., 2012). Prior to the test, each subject performed a 10 minute warm-up session. The subjects, dressed in the appropriate running attire, were not evaluated sooner than two hours post prandially. A single test was performed and a source of motivation was provided. Cones were placed 50 m apart of a measured 400m track. The subjects were instructed to cover the longest possible distance in 12 minutes, running preferably, but walking whenever necessary to prevent becoming excessively exhausted (Cooper, 1968). A prediction of VO_2 peak from the distance covered at the end of 12 minute period was obtained using the formula $VO_{2\ peak}$ = –10.25 + (0.022 x distance in meters)(Montesano et al., 2013)

Harvard Step Test (Physical Fitness Index determination Aerobic Performance)

Harvard step test was performed in the laboratory. Prior to the test the subjects performed a 5-7 minutes warm up consisting of lower limb muscles stretching and brisk walking. The step test began after a brief demonstration and practice period. This test was performed on a wooden stepping bench of 17 inches height with the stepping cadence of 30 cycles/minute which was set by a metronome. The subjects were asked to perform each stepping cycle to a four step cadence, up-up-down-down continuously for 5 minutes. The maximum duration of the test was 5 minutes or upto that moment when the subject exhausted. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 seconds. After exhaustion or completion of the test, the subject was asked to sit and the three recovery heart rates were measured from carotid pulse during 1-1.5 min, 2-2.5 min and 3-3.5 min of the recovery period (Sadhan et al., 2007; Williams, 2010). The physical performance index (PFI) was calculated by the formula PFI= (duration of exercise in seconds x100)/2 x sum of the three recovery heart rates (Sengupta et al., 2011).

Statistical Analysis

All analysis were executed in SPSS for windows version 21.0 and the statistical significance was set at $p \leq 0.05$. The correlation between percent body fat, muscle mass, vertical jump performance, 30 meter sprint test, PFI and VO_{2peak} were calculated using Pearson product moment correlation analysis. Interpretation of correlation coefficients were as follows; $r \leq 0.49$ weak relationship; $0.50 \leq r \leq 0.74$ moderate relationship; and $r \geq 0.75$ strong relationship (Portney and Watkins 2000).

Results

The characteristic features of the sample (n=48) is given in the descriptive statistics in Table I. The results revealed that % BF significantly correlated with tests of aerobic and anaerobic performance. MM was also significantly correlated with anaerobic performance. However, there was no correlation with aerobic performance.

The % BF and 1st anaerobic performance (vertical jump performance) were significantly and weakly negatively correlated ($r = -0.35$, p=0.012) (Fig. 1), where as the % BF and 2nd test of anaerobic performance (30 m sprint time) showed a significant moderate positive correlation($r = 0.59$, $p<0.001$) (Fig. 2). The % BF and 1st aerobic performance (physical fitness index) of the subjects showed a significant moderate negative correlation ($r = -0.32$, p=0.027) (Fig. 3), while a significant moderate negative correlation was seen between % BF and 2nd aerobic performance (VO_{2peak}) ($r = -0.4$, p=0.004) (Fig. 4).

TABLE I : Descriptive statics of the subjects for demographic, anthropometric characteristics and physical performance parameters.

Variable	*Mean±SD*
Age (yrs)	21.06±2.52
Height (cm)	171.86±5.31
Weight (kg)	62.80±5.26
Body Mass Index (BMI)	21.26±1.52
Body Fat (%)	12.49±3.36
Muscle Mass (kg)	27.25±2.84
Vertical Jump Height (cm)	47.51±5.79
30 m Sprint Time (sec)	4.68±0.34
VO_2 Peak (ml/kg/min)	44.94±3.69
Physical Fitness Index (PFI)	71.01±5.86

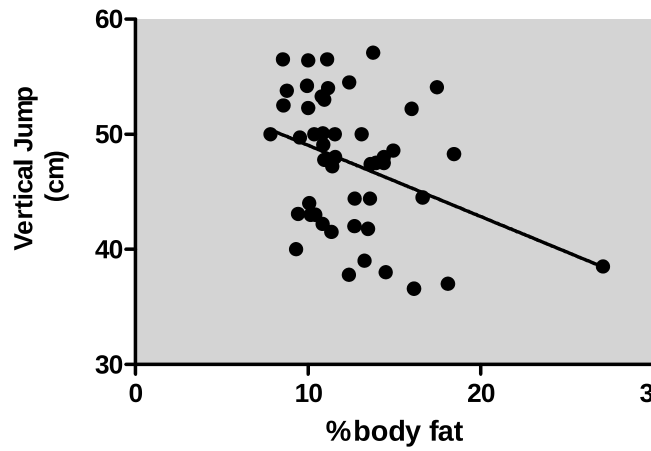

Fig. 1 : Correlation of percent body fat with vertical jump.

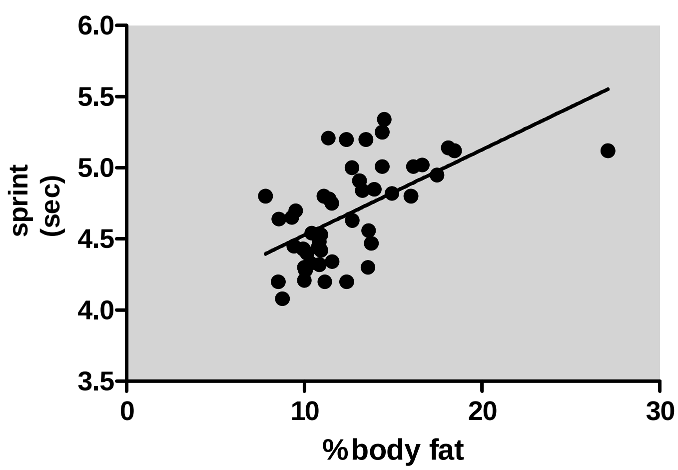

Fig. 2 : Correlation of percent body fat with sprint time.

Muscle mass (MM showed a significant moderate positive correlation with the 1st anaerobic performance (vertical jump performance) ($r = 0.72$, $p<0.001$) (Fig. 5). There was a significant weak negative correlation between MM and 2nd test of anaerobic performance

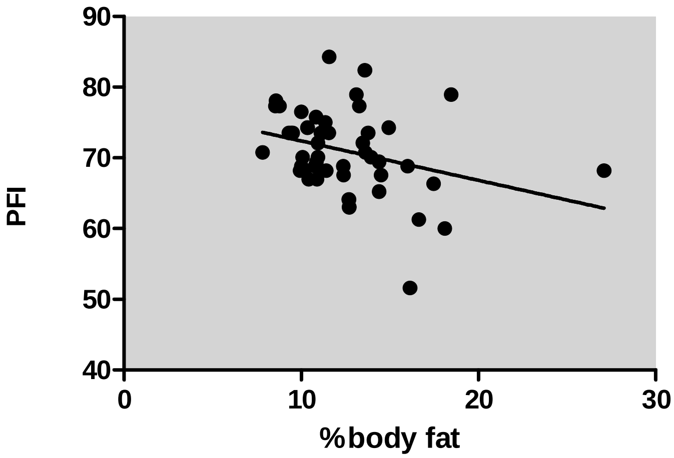

Fig. 3 : Correlation of percent body fat with PFI.

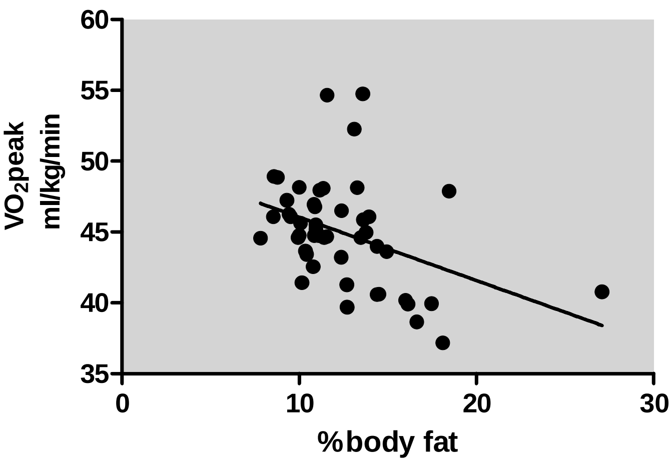

Fig. 4 : Correlation of percent body fat with VO_2peak.

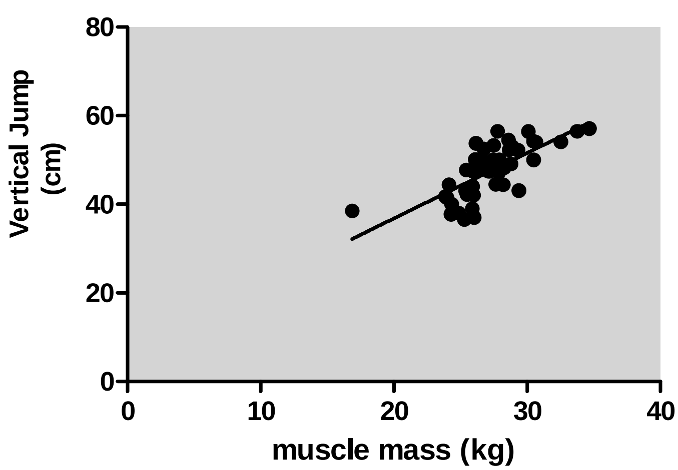

Fig. 5 : Correlation of muscle mass with vertical jump.

(30 m sprint time) (r = –0.35, p=0.013) (Fig. 6). However, no significant correlation was found between

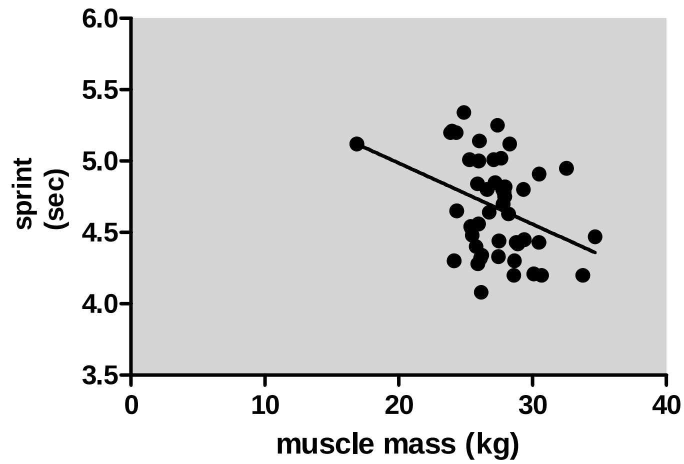

Fig. 6 : Correlation of muscle mass with sprint.

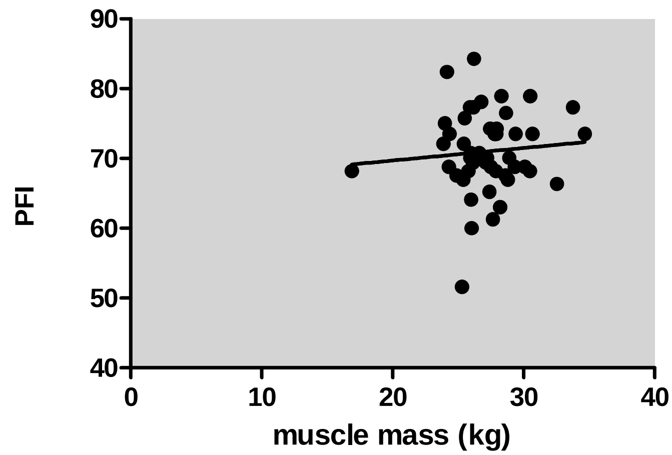

Fig. 7 : Correlation of muscle mass with PFI

muscle mass and 1st aerobic performance test, PFI (r = 0.08, p=0.55) (Fig. 7) and it was same for correlation between MM and 2nd aerobic performance test (VO_2peak) (r = 0.05, p=0.71) (Fig. 8). The correlation of the body composition parameters and performance parameters is given in Table II.

Discussion

The results of the present study suggest that there is a significant weak negative correlation of body fat percentage with vertical jump height and moderate positive correlation of body fat percentage with 30 m sprint time. Previous studies have reported a moderate correlation between percentage body fat, vertical jump and sprint time (Ozkan et al., 2012). It should be noted that these studies were done during

TABLE II : Correlation of Percent Body Fat and Muscle Mass with Aerobic and Anaerobic Performance (using Pearson product moment correlation test)

	VJ		*30 m sprint*		*VO_2 peak*		*PFI*	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
%BF	-0.359	0.012*	0.591	0.000*	-0.406	0.004*	-0.320	0.027*
MM	0.723	0.000*	-0.355	0.013*	0.055	0.712*	0.087	0.556

%BF: percent body fat; MM: muscle mass; VJ: vertical jump; VO_2 peak: peak oxygen consumption; PFI: physical fitness index; r: correlation coefficient; p:probability; *:significant difference

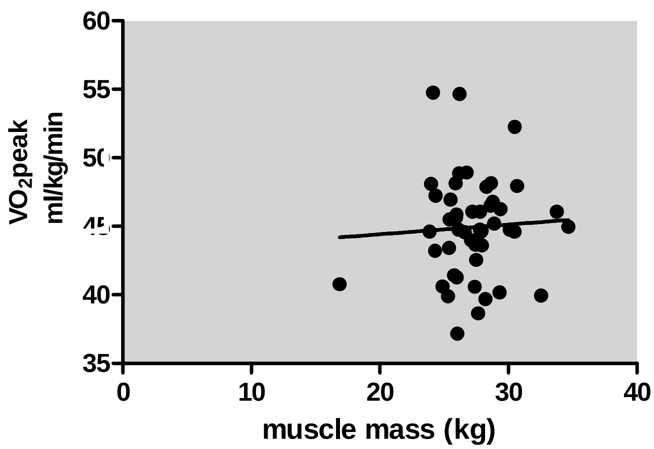

Fig. 8 : Correlation of muscle mass with VO_{2peak}.

the competitive season and on elite soccer players. High body fat is disadvantageous in football because it acts as dead weight, thereby increasing the physiological strain (Rienzi et al., 2000). The correlation of a moderate negative correlation of VO_{2peak} and physical fitness index with percentage body fat were in accordance with previous studies by Koley, 2006 and Sadhan et al., 2007 respectively. According to Cooper (1968), higher fat percentage causes lower performance in activities which involve body displacement. The excess body fat can interfere directly with the jump performance due to increase in body weight, which diminishes the athletes acceleration, since acceleration is equal to force divided by mass. This indicates that soccer players with lower values of percentage body fat may be able to perform better as compared to those with higher percentage body fat values. Thus, gradual and reasonable individual programs of body fat reduction with professional guidance should be recommended in soccer players to improve their physical fitness. However, it may be necessary to pay special attention to individual programs of loss of body fat to avoid the concomitant decrease in muscle mass that has been observed in elite male and female team sports when these programs are performed without professional guidance (Granados et al., 2008) and moreover in this study there is a moderate positive correlation of body fat percentage with 30m sprint time, which shows the drawback importance of body fat in performance.

The results of the present study suggests that muscle mass has a significant moderate positive correlation with vertical jump height and a significant weak negative correlation with 30 m sprint time. Mishra and Chahal, (2013) determined the relationship of muscle mass and anaerobic power in male Indian throwers and found a strong positive correlation. Football players require intensive explosive power in order to kick the ball forward. The high anaerobic power depends on the energy stored in the muscle. Given that sprinting requires high forces, a relationship between muscle mass and sprint time would be expected as muscle mass is the primary determinant of force-power generation (Fitts et al., 1991). Thus, increased muscle mass may be associated with decreased sprint time.To date, the correlation of muscle mass with aerobic performance in collegiate soccer players has not been reported. Although we found one study by Knechtle et al, 2012 who did a study to find out whether muscle mass affects running times in long distance runners, and concluded that muscle mass does not affect running times in master runners. In the present study, the results revealed no significant correlation of muscle mass with both VO_{2peak} and physical fitness index. Therefore, coaches must take into account the body fat rather than the muscle mass when predicting aerobic performance.

Bioelectrical impedance analysis is a method for estimating body composition. It is a rapid, noninvasive, and relatively inexpensive method for evaluating body composition in field as well as clinical settings. It is the most frequently used method because of its ease of operation and its portability. It is also a valid method of predicting muscle mass (Janssen et al., 2000).

Physiological, technical, and tactical skills are all important to soccer performance. Factors such as acceleration, running velocity, jumping height, and capacity to release energy are of major importance (Hoff et al, 2002). Therefore, sprint test and vertical jump test were chosen to assess the running time, jumping height and capacity. Vertical jump test is a more true power test used to measure both vertical jumping distance and power output. The height that is achieved on the vertical jump has a direct correlation with the amount of force that is produced by muscle fibers. This test is inexpensive, easy to assess and no equipment is needed (Changela and Bhatt, 2012). Vertical jump height is a good indicator of anaerobic power (Ostojic, 2000). Harvard step test was chosen because it requires minimal equipment, space and less for time testing. (Jinzhou et al., 2008). While performing step test, heart and lungs, both are in action and therefore it reveals the performance of cardiorespiratory endurance. Cooper 12 min run/ walk test is intended to measure the aerobic fitness of the athlete. The outcome is based on the distance covered and the results can be correlated with VO_{2peak}. Also, when assessing fitness for prolonged physical activity, one must expose the subject to continuous work in order to test him accurately (Cooper, 1968). The major advantage of this test is that it uses a well known type of exercise, i.e., walking and running; it costs minimum to perform; large groups can be run together and trained personnel are not required (Cooper, 1968).

The data in the present study carry considerable practical applications for coaches and athletes. The body composition variables studied can be used as a predictor of performance in collegiate soccer players. It should be useful in future investigation on player selection, talent identification, and training program development. Future studies should be carried out in athletes of various sports, elite athletes and on various performance parameters. A longitudinal study must be carried out in order to find the cause effect relationship in collegiate soccer players. Since the athletes were tested only during the off-season, future researchers may consider testing the athletes in pre-season and competitive season.

Conclusion

The findings of the present study indicate that percentage body fat plays a significant role in both the aerobic and anaerobic performance in collegiate soccer players. However, muscle mass plays a significant role only in anaerobic performance. Therefore, percent body fat, not muscle mass, should be considered by coaches in order to predict the player's aerobic performance.

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