RELATIONSHIP OF VERTICAL JUMP TEST WITH ANTHROPOMETRIC PARAMETERS AND BODY COMPOSITION IN UNIVERSITY STUDENTS – A GENDER VARIATION

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Abstract. Vertical jump test (VJT) is one of the important determinants of physical fitness. VJT score in school going children of West Bengal, India has been reported. However, pertinent data in young sedentary Indian males and females are unavailable. Moreover, the relationship of VJT with anthropometric parameters and different components of body composition has not yet been explored in Indian context. Debatable findings have been reported regarding the impact of body composition on VJT score. The present study was aimed to evaluate the VJT score in young sedentary Indian university students and its relationship with anthropometric parameters and different components of body composition with special reference to gender variation. Healthy sedentary university students (males n = 40 and females n = 40) with similar socio-economic background and age group of 21–25 years were randomly sampled for the study from the post-graduate section of the University of Calcutta, Kolkata, India. VJT was evaluated by Sargent Jump Test, and body composition was determined by skinfold measurements. Body height, body mass, %Fat, Total Fat (TF), LBM and VJT score depicted significant ($p < 0.001$) difference between male and female groups. The VJT scores obtained in the male and female groups were in the range of below average and poor, respectively. Physical parameters did not influence the VJT score in both genders. In the present study the VJT score exhibited significant ($p < 0.001$) negative correlation with %fat, individual skinfold, sum of skinfolds, and TF. Hence, body fat content posed as a hindrance to achieve higher jumping height, especially in females, where the lean mass helped to achieve greater VJT score in males.

Key words: VJT, BMI, body fat, LBM, skinfold

Introduction

Vertical jump test (VJT) is universally used to evaluate and monitor one's explosive leg power and the athletes' leg strength (Sargent 1921; Roschel et al. 2008). The VJT score for male is higher than for their female counterparts. An increase in vertical jump height of international male volleyball players indicated a better performance of explosive strength, elastic-explosive strength, reflex-elastic-explosive strength and a better use of arms during jumps (Borràs et al. 2011). VJT score may differ if different methods of testing are employed (Aragón 2000). Reports also indicated that dynamic quantification of jump ability is useful to evaluate sports performance (Yamamoto and Matsuzawa 2012). Lower extremity power and vertical jumping are significant indices of achieving success in volleyball players (Stec and Smulsky 2007). Studies revealed that efficient performance of volleyball players and other athletes who were involved in jumping activities during the event, largely depend on explosive power and strength of lower extremities (Fattahi et al. 2013). Significant correlation was noted between vertical jump score with a success rate of spike and block in volleyball games (Xing et al. 2006). One of the major criteria to achieve superiority in volleyball, basketball and other similar category of events is to achieve higher jumping ability (Ciccarone et al. 2007). Therefore, the VJT Score has become one of the major determinants of physical fitness in athletes.

It has also been reported that vertical jump score is affected by various physiological and biomechanical parameters (Stangelli et al. 2008). Vertical jump height is independent of body mass and body height in sedentary individuals as well as in sub-elite athletes but negatively correlated with body fat percentage (Markovic and Jaric 2007; Davis et al. 2003; Aslan et al. 2011).

Therefore, individuals with lower %fat are supposed to have the advantage in vertical jumps (Davis et al. 2003). Noorul et al. (2008) studied the predictor factors which determine physical fitness parameters including vertical jumping of amateur athletes, although no significant relationship was found between anthropometric parameters with jumping ability.

VJT score in school going children of West Bengal, India has been reported (Chatterjee et al. 2004). But pertinent data in young sedentary Indian males and females are unavailable. Moreover, the relationship of VJT with anthropometric parameters and different components of body composition has not yet been explored in Indian context. Therefore, the present study was conducted to

- evaluate and compare the VJT score in young males and females of Kolkata, India,
- find out the relationship of VJT score with anthropometric parameters and different components of body composition in the studied population.

It has been hypothesized that there will be significant relationship of one or more physical parameters and different components of body composition with VJT score.

Materials and Methods

Selection of Subjects

Healthy sedentary male (n = 40) and female (n = 40) subjects with similar socio-economic background and belonging to age group of 21–25 years were selected for the study by simple random sampling from the post-graduate section of the University of Calcutta, Kolkata, India. Subjects were neither suffering from any diseases nor under any medication during the study period. They had no history of previous bone fracture or heavy injury.

The study was conducted at a room temperature ranging between 20–23°C and relative humidity ranging between 40–45%.

Age of each subject was calculated in nearest year from the date of birth as obtained from the University record. After arrival in the laboratory, subjects were allowed to take rest for half an hour. Body height was measured with the subject standing barefoot with an accuracy of +0.50 cm whereas the body mass was measured to an accuracy of +0.1 kg by using weight measuring instrument fitted with height measuring rod (Avery India Ltd., India) with the subject wearing minimum clothing. Pre-exercise heart rate and blood pressure were measured (Chatterjee et al. 2004).

Ethical clearance was obtained from the Human Ethics Committee of the Department of Physiology, University of Calcutta, and written informed consent was taken from all the subjects.

Determination of Body Composition (Jackson and Pollock 1978; Siri 1961)

Body composition was determined by skinfold measurement by using the following formulae:

Body density (BD; $gm.cc^{-1}$) was determined from the following equations:

Females: $BD = 1.0994921 – 0.0009929\ X_1 + 0.0000023\ X_1^2 – 0.0001392\ X_2$

(X_1 = sum of triceps, suprailiac, thigh skinfolds, X_2 = Age in nearest yrs)

Males: $BD = 1.10938 – 0.0008267X_1 + 0.0000016X_1^2 – 0.0002574X_2$

(X_1 = sum of chest, abdominal, thigh skinfolds, X_2 = Age in nearest yrs)

% Fat = 495/BD – 450.

Total body fat, percentage of lean body mass (%LBM) and total LBM were calculated using the following equations:

Total Fat or TF (kg) = %Fat/100 × Body Mass (kg),

% Lean Body Mass (%LBM) = 100 − %Fat,

LBM (kg) = Body Mass (kg) − Total Fat (kg).

Determination of VJT Score

The VJT Score of each subject was evaluated according to the procedure elaborated in earlier reports (Chatterjee et al. 2004). The subject chalked the end of his/her finger tips. Subject stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height (M_1). The athlete then stands away from the wall and from a static position jumps vertically as high as possible with the attempt to touch the wall at the highest point (M_2) of the jump. The distance between M_1 and M_2 was measured and recorded. The subject repeated the test 3 times with a gap of at least 10 minutes between the consecutive trials and the best of these three efforts was recorded.

Statistical analyses

Data have been presented as mean ±SD. Students t-test was adopted to find out the significance of difference between means. Pearson's product moment correlation was conducted to compute the relationship between physical parameters and VJT score. Regression analysis was adopted to compute the prediction norms for predicting VJT score from different physical parameters.

Results

The mean values of age, body weight, body height, BMI, %Fat, TF, LBM and VJT score were presented in Table 1. Age and BMI did not show any significant difference between the groups. However, body height, body mass, %Fat, TF, LBM and VJT score depicted significant ($p < 0.001$) difference between male and female groups. VJT score obtained in male and female groups were below average and poor, respectively (Arkinstall 2010). The values of correlation coefficient of VJT score with physical parameters, skinfolds and different components of body composition have been tabulated in Table 2. Regression equations for the prediction of VJT score from physical parameters in the studied population have been computed (As shown in Table 3 and Table 4).

Table 1. Values of physical and anthropometric parameters and vertical jump score in male and female University students of Kolkata, India

	Age (yrs)	Weight (kg)	Height (cm)	BMI (kg/m^2)	% Body fat (%)	Total Fat (kg)	LBM (kg)	VJT Score (cm)
Male (n = 40)	23.1 ±2.24	59.26 ±3.48	167.21 ±6.3	21.25 ±1.56	13.37 ±2.50	7.91 ±1.51	51.34 ±3.50	47.00 ±5.93
Female (n = 40)	23.75 ±1.58	50.93 ±4.02**	153.76 ±3.6**	21.56 ±1.80 NS	17.37 ±3.01**	8.85 ±1.74*	42.06 ±3.52**	22.05 ±5.75**

Values are expressed as mean ±SD, ** $p < 0.001$,* $p < 0.05$.

Table 2. Values of correlation coefficient of VJT scores with different anthropometric parameters in both the genders

		Age (Yrs)	Body weight (kg)	Body height (cm)	BMI (kg/m^2)	Sum of Skinfolds (mm)	%Fat (%)	TF (kg)	LBM (kg)	VJT (cm)
Age	M		0.06	0.22	−0.14	−0.05	0.05	0.06	0.04	−0.07
	F		0.54***	−0.01	0.52***	0.03	−0.01	0.18	0.52***	−0.19
BW	M			0.41**	0.38*	−0.10	−0.10	0.19	0.91***	0.19
	F			0.18	0.83***	0.12	0.1	0.49**	0.9***	−0.15
BH	M				−0.67***	−0.12	−0.9***	−0.01	0.4**	−0.08
	F				−0.39*	−0.52***	−0.53***	−0.39*	0.39*	0.07
BMI	M					0.04	0.01	0.15	0.31	0.20
	F					0.39*	0.38*	0.66***	0.61***	−0.17
Sum of Skinfolds	M						0.99***	0.94***	−0.51***	−0.89***
	F						0.99***	0.92***	−0.32*	−0.80***
%Fat	M							0.95***	−0.51***	−0.90***
	F							0.92***	−0.34*	−0.80***
TF	M								−0.23	−0.83***
	F								0.049	−0.76***
LBM	M									0.55***
	F									0.21
VJT	M									
	F									

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; M = male group; F = female group.

Table 3. Simple regression norms for the prediction of VJT score in male and female University students Kolkata, India

Parameter	Simple regression equation	SEE
VJT	VJT = 75.54 – 2.13% of body fat	2.58
VJT	VJT = 72.78 – 3.26 TF	3.30
VJT	VJT = 75.94 – 0.62 sum of skin folds	2.70
VJT	**VJT = 48.59 – 1.53% of body fat**	**3.45**
VJT	**VJT = 44.28 – 2.51 TF**	**3.73**
VJT	**VJT = 52.22 – 0.47 sum of skin folds**	**3.45**

Values in bold indicates the female groups.

Table 4. Multiple regression norms for the prediction of VJT score in male and female University students Kolkata, India

Parameter	Regression Equation	R	R^2	SEE
VJT	VJT = 76.65 – 0.71sum of SF – 0.47 TF	0.899	0.8082	0.44
VJT	**VJT = 51.07 – 0.38 sum of SF – 0.52 TF**	**0.802**	**0.6432**	**0.60**

Values in bold indicates the female groups. SF = Skin Folds.

Discussion

The rational of the current study was to verify whether the anthropometric factors have any significant effect on vertical jump height among university students of Kolkata, India on a gender basis. The study exposed the hypothesis – one is that males have higher VJT score than the females, and the second hypothesis is that significant relationship exists between VJT score and anthropometric factors in both genders.

In the present study body height, body weight and VJT score were significantly ($p < 0.001$) higher in Indian males than female university students as also reported in Turkish population (Arkinstall 2010; Coksevim and Caksen 2005; Burkett et al. 2005). However,the values obtained in male and female groups were in the category of “average” and “poor”, respectively (Arkinstall 2010).

Earlier study reported significant positive correlation of height with VJT score in male elite volleyball players (Stec and Smulsky 2007). In the present study no significant correlation was found between height and VJT score in male and female university students. This observation corroborated with the earlier study (Nahdiya 2013).

There was a significantly higher VJT score in male adolescent Malaysian taekwondo players than their female counterparts (Noorul et al. 2008). Significantly ($p < 0.01$) higher values of VJT score in Indian male university athletes than their female counterparts were also observed in the present investigation. Significantly higher value of VJT score as also reported in teenage boys than teenage girls (Coksevim and Caksen 2005; Maud and Shultz 1986; Cazas et al. 2013). Such higher values of VJT scores in males were attributed to stronger physique of males than their female counterparts (Nahdiya 2013).

Body fat % is related to the work performance during vertical jump. In the present study the VJT score exhibited significant ($p < 0.001$) negative correlation with %fat, individual skinfold, sum of skinfolds, and TF. However, LBM exhibited significant negative correlation with VJT score only in males. Similar findings were also reported (Nahdiya 2013).

The gender difference in jump height is also related to the body fat percentage (%fat). Generally, females have a larger body %fat especially due to the stored fat in the hip and chest portion of the body, hence, male individuals who have a lower body %fat have the advantage in vertical jumps (Noorul et al. 2008). Body %fat is the best predictor of vertical jump for recreational male athletes. Sum of skinfold thicknesses has significant negative correlation with VJT score as also observed in the present investigation. Since work is the product of average force acting on the subject and the displacement of the jump, heavier athletes need more work to move the body to the same displacement achieved by lighter athletes (Roschel et al. 2008). Hence, an individual with lower body fat percentage will be able to generate more jumping height (Noorul et al. 2008; Janine et al. 2012).

One peculiar finding in the study is that the LBM is positively correlated with VJT score in males while in females insignificant correlation was found between LBM and VJT. Previous studies did not report such findings in their population. Lean tissue is the source of energy that is directly associated with the VJT score in male subjects of the present investigation. That might be another basis to explain the existence of higher jumping ability in males than females. On the other hand, it may be justified to speculate that in the female group, VJT score had significant negative correlation with both %fat and TF that acted as an inert mass as far as the energy production is concerned and therefore the fat mass might have hindered the jump height in female participants.

In the present study, body mass and body height did not affect the VJT score in both the genders as well as was shown earlier (Davis et al. 2003). VJT score is independent of body mass and BMI. Therefore, assessment of VJT based on body mass or BMI alone tends to be misleading because neither of these parameters differentiates the proportion of FM, LBM or muscle mass out of the total body mass (Maud and Shultz 1986; Shin et al. 2012). But, the contradictory finding of existence of significant correlation of VJT score with age, body height and body mass in school going Indian boys and girls (Chatterjee et al. 2004). However, body height should not be a major concern in the context of VJT score because the technique used to improve the power would be able to compensate for the influence of height on VJT (Janine et al. 2012). The present findings are in agreement with that of the study for ballet dancers (Wargocki and Wyon 2006). Though they hypothesised that vertical jump is affected by individual height, their result confirmed otherwise. Similarly, among sub-elite athletes performance, no significant relationship was found between height and vertical jump (Aslan et al. 2011).

Simple regression equations have been computed to use as norms for the prediction of VJT score from %fat, sum of skin folds and total fat (TF). Multiple regression equations were also computed to predict VJT score in both genders from the sum of skinfolds and total fat (TF). In the multiple regression equations %fat was not considered as a predictor variable since it is calculated from sum of skinfolds. Standard errors of estimate (SEE) of the computed multiple regression equations were smaller than the simple regression equations, and the values of these SEE were substantially small enough to recommend the multiple regression norms for practical use in epidemiological studies and also in clinical settings.

Conclusions

The VJT scores obtained in the Indian male and female groups were in the range of below average and poor, respectively. The body mass and body height did not influence the VJT score in both the genders. Body fat content posed as a hindrance to achieve higher jumping height especially in females, where the lean mass helped to achieve greater VJT score in males. However, among other anthropometric parameters, VJT had significant negative correlation with individual skinfold and sum of all the skinfolds in male and female university students of Kolkata, India.

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