Anthropometric Correlates of Anaerobic Power

Rajib Biswas[1] and Alok Ghosh Chaudhuri[2]

Department of Physiology, [1]Himachal Dental College, Himachal Pradesh, [2]Vidyasagar College, Kolkata

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Corresponding Author

Rajib Biswas. E-mail: *ergoraj@rediffmail.com*

ABSTRACT

Introduction and Aim: The present paper intends to correlate the results of vertical jump test with different anthropometric parameters.

Materials and Methods: Eastern Indian schoolboys from the similar socio-economic background were selected. Vertical jump height (VJH) score and anaerobic power (AP) were two performance attributes considered which are correlated with Height (Ht), Weight (Wt), Body Mass Index (BMI) and Ponderal Index (PI).

Results: Mean VJH (26.5 ± 9.6 cm) was found to be lower than earlier studies. AP was 44.6 ± 21.8 kg-m/sec. Inter-correlation coefficients among all anthropometric parameters except PI with VJH and AP scores ranged between 0.22 – 0.93 ($p < 0.01$). The increasing trend of VJH and AP scores with age is clearly noted. A similar trend was also observed for height and weight. Multiple regression of AP with height and weight in three different age groups viz., 7 – 10, 11-14 and 15 – 18 years and as well as for the whole group yields an R^2 value ranging between 0.42 – 0.88.

Conclusion: Performance is greatly influenced by factors like age, height, and weight. Association of Wt and BMI with AP and VJH score can be correlated with their already established relation with muscularity, which in turn can directly affect anaerobic power. Since muscularity, leanness and body fat percentage are not included in the present study, their relative contributions in determining AP have been indicated as a further scope of research.

Key Words: Anaerobic power, Vertical jump test, Height, Weight, Anthropometry.

INTRODUCTION

Anaerobic power is the maximum ability of the anaerobic system to produce energy per unit of time. Anaerobic energy production is primarily a function of the Adenosine Triphosphate, phosphocreatine system (ATP – PC) system present in the skeletal muscles, which causes the instant release of energy from ATP breakdown with subsequent rapid regeneration of PC. This energy generates maximal muscle power in short bursts of activities. However, due to limited CP stores in muscles, this system can produce energy for a limited period lasting maximally for 8 – 10 seconds (1, 2).

Direct measurement of anaerobic power by measuring the ATP - PC stores is complicated and uses the invasive technique of muscle biopsy. However, this procedure has been successfully replaced by performance measure of anaerobic power. These alternative procedures are presented as field test methods. As a principle, the test employs very short bursts of high-intensity exercise which momentarily mobilize and expend maximum amount of energy that releases instantaneously from the muscle pool of high energy phosphates (3). In accordance, various test protocols have been developed and successfully administered for years (4-6).

Vertical Jump test (VJT) originally described by Sargent (4) has been widely accepted as a valid measure to estimate the anaerobic power generating the capacity of an individual. Recent studies have indicated that power output in the vertical jump is strongly associated with weightlifting ability and can be a valuable tool in assessing weightlifting performance (7). This test has been used to assess the maximum power of volleyball players (8, 9) and has also been introduced as a standardized test to evaluate the anaerobic fitness of basketball player (10) and to assess athletic performance (11, 12). The vertical jump test has also been advised as one of the major anaerobic training items in the physical fitness programs (10).

Recent data on vertical jump test in the Indian context is still scanty. Some earlier studies have reported vertical jump scores for school going boys and girls (13) and junior badminton players (14) from

Eastern India. However, no attempt so far has been documented to correlate these values with anthropometric measures. In the present study, attempt has been made to report vertical jump scores for children and pre-adolescent boys and to correlate the anaerobic power generating capacity with fundamental anthropometric measures like height, weight and some other derived anthropometric indices.

MATERIALS AND METHODS

Subjects

A total of 143 boys within the age group of 7 – 18 years were selected from different schools of North - 24 Pargana district of West Bengal, India to volunteer in the study. All of them were selected from a preselected population with matched daily habits, similar engagement in recreational sports activity for 2 hours per day and 3-4 days per week and similar socio-economic background and dietary patterns. All the subjects were from middle- class families.

Prior to subject election, a letter explaining the brief plan of the study was presented to the school management as well as to the parents for consent. Both the parents and children were explained about the study and the extent of their involvement.

Investigation

Height and weight of the subjects were obtained using an anthropometric rod and human weighing machine. Body Mass Index (BMI) was obtained from weight in kg divided by the square root of the height in meters. The height and weight of the subjects were also used to obtain the Ponderal Index (PI), calculated as the cube root of the weight (kg) divided by the body height (cm).

All subjects performed three trials of vertical jump as per protocol (4). Before the test, the subjects were explained and demonstrated about the procedure. In accordance, the subjects stood erect by a wall with both heels touching the floor. In this position they were asked to extend their arms vertically as far as possible and make a mark with their fingers dipped in chalk dust. This was designated as the standing reach. Next they were asked to jump and touch a height at their maximal possible extent and make a mark again. This height was termed as jump reach. The difference of jump and standing reach – the vertical jump height (VJH) was measured in cm. The best of the three trials were recorded and before each trial the subjects were verbally encouraged to beat their previous score. Finally the VJH is converted to anaerobic power (AP) expressed in kg – meter/sec from the Lewis nomogram (6) by the following formula:

Anaerobic power (kg – m /sec) = $\sqrt{4.9}$ x Wt (kg) x $\sqrt{\text{VJH (m)}}$.

Statistical Analysis

Descriptive statistics including mean and standard deviations (SD) were generated from the data. Pearson product moment correlation coefficient was determined to judge the relationship between different anthropometric parameters and power scores. One way ANOVA was used to compare means of several parameters studied among different age groups and linear multiple regressions models were computed to assess anaerobic power from anthropometric parameters.

RESULTS

Physical characteristics and anaerobic power for the whole group

Descriptive statistics for different anthropometric parameters and anaerobic power scores are summarised in table 1. A wide dispersal of the data is apparent from the range of different parameter studied. The matrix of correlation between different parameters is presented in table 2. It is conspicuous from the table that PI showed least association with all parameters except BMI. In contrast, all the other anthropometric parameters showed significant positive association among themselves and also with the VJH score and anaerobic power. Furthermore, the interrelation between the VJH score and anaerobic power appeared insignificant.

Table 1: Anthropometric characteristics and power scores of the subjects (n= 143)

Parameters	Mean ± SD (Range)
Age (years)	12.2 ± 3.1 (7 – 19)
Height (cm)	147.1 ± 15.2 (113 – 175)
Weight (kg)	40 ± 13.1 (19.5 – 77.0)
BMI (kg/m2)	18.0 ± 3.2 (12.9 – 27.6)
Ponderal Index x103	23.03 ± 1.25 (20.6 – 27.4)
Vertical Jump Height (VJH) (cm)	26.5 ± 9.6 (9.3 – 51.4)
Anaerobic Power (kg – m/sec)	44.6 ± 21.8 (10.4 -106.8)

Table 2: Correlation matrix among different anthropometric parameters and power scores of the subjects (n=143)

	Age	height	Weight	BMI	PI	VJH	AP
Age		0.84 *	0.79 *	0.47 *	-0.03 (ns)	0.71*	0.87 *
Height			0.85 *	0.40 *	-0.21 ***	0.67*	0.87 *
Weight				0.81 *	-0.31 *	0.54 *	0.93 *
BMI					-0.81*	0.22**	0.64 *
PI						-0.18***	- 0.13(ns)
VJH							0.78 *
AP							

*** p < 0.001; ** P < 0.01; *** p < 0.05; ns: non-significant**

Relation between anthropometric and anaerobic power profile with age

For a comprehensive assessment of the anaerobic power the entire group of subject was subdivided into three age group classes, viz; 7 – 10 (mean age 8.8 ± 1.11) years, 11-14 (mean age 12.4 ± 1.14) years, and 15 – 18 (mean age 16.6 ± 1.37) years. Descriptive statistics of different parameters of the age groups is summarised in table 3. It appeared that the subjects of different age groups differ significantly in terms of all the parameters studied. All the parameters except PI were lowest in 7 – 10 years and highest among the 15 -18 years age group while 11-14 age group demonstrated intermediate value. However, this pattern was not followed for the PI. The increasing trend of all the parameters with age except PI is also reflected in positive significant correlation coefficient as presented in table 2.

Table 3: Anthropometric profiles and anaerobic power scores in different age groups

Parameters	Age group (year) Classes			Results of ANOVA
	7 – 10 (n= 47)	11 – 14 (n= 63)	15 – 18 (n=33)	
Height (cm)	131.8 ± 7.3	149.4 ± 11.0	164.2 ± 7.4	f= 125 p= <0.001
Weight (kg)	29.2 ± 5.9	39.8 ± 9. 6	55.7 ± 10.1	f= 90.1 p= <0.001
BMI (kg/m2)	16.7 ± 2.7	17.7 ± 3.0	20.6 ± 2.9	f= 18.1 p= <0.001
Ponderal Index x 103	23.3 ± 1.2	22.7 ± 1.3	23.2 ± 1.1	f= 3.1 p= <0.05
VJH (cm)	18.2 ± 5.1	27.8 ± 7.7	33.6 ± 9.15	f= 46.6 p= <0.001
Anaerobic Power(kg-m/sec)	22.3 ± 8.6	46.3 ± 14.4	73.1 ± 15.0	f= 146.3 p= <0.001

Regression equations generated for predicting anaerobic power from anthropometric parameters viz, height and weight for different age groups are summarised in table 4. The models were derived using height and weight as variables and AP (kg –m) as criterion variable (Y).

Table 4: Relationship among height weight and anaerobic power in different age groups

Age group (years)	Relation	R	R^2	SE	p	Regression
7 – 10	Age vs Height	0.47	0.22	7.7	< 0.001	Y= Ht x 0.547 - 49.81
	Age vs Weight	0.64	0.41	6.6	< 0.001	Y = Wt x 0.928 – 4.83
	Age vs Ht and Wt	0.65	0.42	6.7	< 0.001	Y = Ht x 0.135 + Wt x 0.825 -19.61
11- 14	Age vs Height	0.71	0.50	10.2	< 0.001	Y= Ht x 0.927 – 92.10
	Age vs Weight	0.88	0.77	6.9	< 0.001	Y = Wt x 1.31 – 5.92
	Age vs Ht and Wt	0.89	0.79	6.7	< 0.001	Y = Ht x 0.223 +Wt x 1.131 -32.0
15 – 18	Age vs Height	0.63	0.40	11.8	< 0.001	Y= Ht x 1.274 – 136.11
	Age vs Weight	0.83	0.70	8.3	< 0.001	Y = Wt x 1.24 +3.75
	Age vs Ht and Wt	0.85	0.72	8.1	< 0.001	Y = Ht x 0.395 +Wt x 1.066 – 51.26
Whole group	Age vs Height	0.87	0.76	11.1	< 0.001	Y= Ht x 1.310 – 148.10
	Age vs Weight	0.93	0.86	8.6	< 0.001	Y = Wt x 1.615 -20.00
	Age vs Ht and Wt	0.94	0.88	7.8	< 0.001	Y = Ht x 0.468+Wt x 1.151 -70.29

DISCUSSION

Average VJH score for all the subjects as obtained in this study is lower than Eastern Indian school going boys and junior badminton players with a mean of 34.9 ± 6.3 cm and 33.0 ± 9.0 cm respectively but comparable to that of school going girls (26.5 ± 4.4 cm) of 10 – 16 years of age (13, 14). Considering the VJH score in similar age groups as obtained in previous studies, the current study yields an average VJH score of 27.6 ± 8.2 cm which was still lower.

It has been acknowledged that performance is greatly influenced by factors like age, height, and weight. In the present study performance, scores are well correlated with age, height, weight, and BMI except for PI. The ponderal index used in the present study was constructed considering the fact that weight is the result of a three-dimensional expansion of the body, and thereby represents a valid indicator of body stoutness (15).

Although the relationship of PI with muscle strength is not well documented, an apparent low negative correlation between PI both with VJH and AP scores in the present study may be attributed to the fact that ponderal index implies the body position in relation to ectomorphy which reflects thinness. This is opposed to mesomorphy which is characterized by muscularity (16) that positively influences the anaerobic power output of an individual.

It is easily assumed that muscular strength and relative muscularity have got direct influence on anaerobic power and the relation between muscular strength, performance and anthropometric profile have been well established in different kinanthropometric studies (17-19). This may be further established by the fact that vertical jump score is a well predictor of muscle strength and has been found significant in predicting leg strength (20). Again correlation obtained by knee extensor muscular strength with vertical jumping height and peak power yield strong to the moderate relationship among women volleyball players (21). The choice of body mass index in the present study is influenced by the fact that it represents one of the best indices for assessment of nutrition, growth status and body composition for school-age children and adolescent (22) and has also been used to evaluate the leanness among Indian children (23). It is also highly correlated with body weight (24) and reported to have a strong positive association with muscularity ($r = 0.66$, $p< 0.001$) among Eastern Indian 'Bengalee' boys (25). Considering the effect of muscularity on the jump height and AP scores, the relationship between muscularity and BMI can, therefore, be assumed as an explanation for the positive association of BMI with AP and VJH score as obtained in the present study. It can be noted that the coefficient of correlation obtained between BMI and VJH score is almost similar to that obtained in a previous study conducted among young adults (26).

The weight in the present study is more associated with AP as compared to VJH. This can be partly attributed to the fact that the Lewis method directly includes body weight as a factor in determining anaerobic power. Moreover, since weight has a high relationship with developmental level and influences muscularity, it, therefore, acts as a determining factor for strength and anaerobic power measures. This has been reflected in strength test performances relying on anaerobic power (27).

A conspicuous increasing trend was observed in the anaerobic power score with increasing age that parallels with a similar trend for height and weight of the subjects. The observed growth pattern of the subjects in relation to height and weight is in well conformation with the results obtained for similar eastern Indian population (28).

The higher values of VJH and AP scores of the subjects in different age groups in ascending order may be attributed to their increased height and weight with age which could have influenced the anaerobic power scores. A very early study conducted by Dawson (29) reported a rising trend in AP scores with age advancement upto middle age.

Based on the protocol of the experiment it can be stated that height has a positive influence on the VJH as taller subjects will likely to have more reach scores. It is also evident that this relationship is subjected to variation by individual muscularity. The subjects selected in the present study are not trained for a particular sports activity that may influence the muscle build. Moreover, as per the selection criteria, they can be considered homogenous on the source of socio-economic background which is observed to have an influence on the dietary pattern thereby influencing growth status (30). The average BMI of the subjects in this study was obtained to be 18 which can be classified as thin (31) indicative of a lower musculature. Now, based on an assumed equality of nutritional status of the subjects it can be stated that VJH and following AP score might have been more influenced by the stature than muscularity in this case. The 'thinness' of the boys under present investigation may be responsible for a lower value of VJH score as compared to the previous findings mentioned earlier (13,14). From this could be humbly acknowledged that assessment of muscularity along with leanness and fat percentage, which was not considered in the present study, can be proved to be a better estimator of AP and evaluation of their relative contributions in VJH and AP thus represent a potential scope of the future study.

CONCLUSION

As like other methods of classifying anaerobic power in relation to age, the present study has generated regression equations to predict anaerobic power from height and weight for different age group categories, each with high R^2 values. These equations may be useful for assessment of anaerobic power in large-scale studies and primary evaluation of ones capability to different field events requiring short bursts of muscle activity.

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