Anthropometry and Body Composition in Soccer and Volleyball Players in West Bengal, India

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Abstract 50 sedentary males and 128 sportspersons (volleyball=82, soccer=46) of 20–24 years were selected from West Bengal, India, to evaluate and compare their anthropometry and body composition. Skinfolts, girth measurements, body fat percentage (%fat), and endomorphy were significantly higher among sedentary individuals, but lean body mass (LBM) and mesomorphy were significantly ($p<0.001$) higher among the sportspersons. Soccer and volleyball players were found to be ectomorphic mesomorph, whereas sedentary subjects were endomorphic mesomorph. The soccer and volleyball players had higher %fat with lower body height and body mass than their overseas counterparts. %fat exhibited a significant correlation with body mass index (BMI) and thus prediction equations for %fat from BMI were computed in each group. The present data will serve as a reference standard for the anthropometry and body composition of Indian soccer and volleyball players and the prediction norms for %fat will help to provide a first-hand impression of body composition in the studied population. *J Physiol Anthropol* 26(4): 501–505, 2007 <http://www.jstage.jst.go.jp/browse/jpa2>
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Introduction

Body composition, anthropometric dimensions, and morphological characteristics play a vital role in determining the success of a sportsperson (Wilmore and Costill, 1999; Keogh, 1999; Reco-Sanz, 1998). These parameters are sensitive indicators of the growth progress and nutritional status of a population that is ultimately relevant to a specific event in which the subject excels (Chatterjee et al., 2006; Wilmore and Costill, 1999). These indicators of prospective sports performance largely depend on heredity and are correlated with age, gender, ethnicity, food habit, and

exercise practice (Bouchard and Lortie, 1984; Fagard et al., 1991). Proper evaluation of these parameters reflects the quantification of the body's major structural components, which are required in different proportions for various games to achieve excellence (McArdle et al., 1986).

Despite concern about the fact that morphological parameters are an essential part of the evaluation and selection of sportspersons for diverse fields of sports, standard data on such parameters are still lacking in the Indian context of soccer and volleyball games. The present study was therefore aimed at evaluating the physical parameters, anthropometric measurements, body composition and somatotype of soccer and volleyball players in West Bengal, India, and to compare the data with their sedentary counterparts.

Methods

178 healthy young male subjects (sedentary=50, soccer player=46, volleyball player=82) of 20–24 years and having similar socio-economic background were investigated for the study. Sedentary individuals were selected by simple random sampling from the postgraduate section of the University of Calcutta, whereas the state level sportspersons were recruited from various sports academies in West Bengal, India. The age of each subject was calculated from the date of birth as recorded in his institute. The body mass and body height of each subject were measured by using a weighing scale (Inco, Ambala, India, Model No. 4516 PXL) fitted with a height measuring stand. Body surface area (BSA) and body mass index (BMI) were calculated by the following formulae :

$$\begin{aligned} \text{BSA (m}^2\text{)} &= (\text{Body mass in Kg})^{0.425} \\ &\quad \times (\text{Body Height in cm})^{0.725} \\ &\quad \times 0.007184 \end{aligned}$$

(DuBois and DuBois, 1916)

$$\text{BMI (Kg/m}^2\text{)} = (\text{Body mass in Kg}) / (\text{Stature in Meters})^2$$

(Meltzer et al., 1988)

Skinfolts and anthropometric measurements (viz., girths

and widths) were measured by Holtain Skinfold Caliper with constant tension (Holtain Ltd., UK) and measuring tape with anthropometric rod, respectively, according to the guidelines of Johnson and Nelson (1982).

Somatotype was determined from the following equations (McArdle et al., 1986):

- (i) Endomorphy = $0.1451(X) - 0.00068(X)^2 + 0.0000014(X)^3$
(Where X = sum of supra-spinal, subscapular and triceps skinfold and corrected for stature by multiplying the sum of skinfolds by 170.18/Body Height in cm)
- (ii) Mesomorphy = $(0.858 \times \text{Humerus width}) + (0.601 \times \text{Femur width}) + (0.188 \times \text{Corrected arm girth}) + (0.161 \times \text{Corrected Calf Girth}) - (\text{Body Height } 0.131) + 4.5$
(Where Corrected Arm Girth = Arm girth - Biceps skinfold, Corrected Calf Girth = Calf Girth - Calf Skinfold)
- (iii) Ectomorphy = $(\text{HWR} \times 0.732) - 28.58$
[Where HWR = (Body Height in cm) / (weight in kg)^{1/3}]

Body composition was measured from skinfold measurements by using the following equations (Bandyopadhyay and Chatterjee, 2003):

Body Density or BD (gm/cc) = $1.10938 - 0.0008267 X + 0.0000016 X^2 + 0.0002574 Y$

(Where X = sum of chest, midhigh, and abdominal skinfolds and Y = Age in years)

(Jackson and Pollock, 1978)
%fat = $(4.95/\text{BD}) - 4.5$ (Siri, 1956)

% Lean Body Mass (%LBM) = $100 - \% \text{fat}$

Total fat or TF (Kg) = $(\% \text{fat}/100) \times \text{Body mass (Kg)}$

Lean Body Mass or LBM (Kg) = $\text{Body Mass (Kg)} - \text{TF (Kg)}$

Informed consent was taken from each subject and the entire work was carried out after receiving permission from the ethics committee.

Statistical Analysis:

ANOVA, Pearson's product moment correlation, and linear regression analysis were undertaken for the statistical treatment of the data.

Results

The physical parameters of sedentary individuals, soccer players and volleyball players are presented in Table 1. The BMI values showed that the subjects were non-obese, non-overweight and almost thin according to the available classification (Chatterjee et al., 2006; Meltzer et al., 1988). Table 2 represents the values of different skinfold measurements in all the groups, whereas Table 3 indicates the arm girth, calf girth, humerus width, and femur width. The values of different components of body composition are presented in Table 4 and somatotype scores in all the groups are plotted in Fig 1.

Table 1 Physical parameters of the sedentary individuals and sportspersons

Category	Age (Yrs)	Body Height (cm)	Body Mass (kg)	BSA (m ²)	BMI (kg/m ²)
Sedentary (N=50)	22.06 ±1.35	165.10 ±3.90	55.50 ±6.01	1.604 ±0.093	20.33 ±1.71
Soccer (N=46)	22.00 ±1.69	166.00 ±4.31	56.53 ±7.62	1.623 ±0.118	20.56 ±1.89
Volleyball (N=82)	22.30 ±1.36	173.10 ±4.19 *	58.87 ±6.94 **	1.702 ±0.111 **	19.59 ±1.57

Values are mean ± SD

* $p < 0.001$, ** $p < 0.01$ (When compared by ANOVA)

Table 2 Different skinfold measurements of the subjects

Category	SKINFOLDS (mm)									
	(i) Biceps	(ii) Triceps	(iii) Sub-scapular	(iv) Supra-iliac	(v) Chest	(vi) Abdominal	(vii) Mid-thigh	(viii) Supra-spinal	(ix) Calf	Sum (i-ix)
Sedentary (N=50)	4.98 ±1.29	9.40 ±2.44	13.03 ±4.36	12.82 ±4.16	14.53 ±5.27	16.33 ±5.90	17.75 ±6.61	12.84 ±3.80	11.27 ±3.82	112.95 ±32.68
Soccer (N=46)	3.03 ±0.48 *	5.48 ±1.58 *	8.32 ±3.17 *	6.08 ±2.90 *	5.47 ±1.80 *	5.02 ±1.93 *	8.09 ±2.90 *	8.05 ±2.80 *	6.75 ±2.57 *	56.30 ±18.07 *
Volleyball (N=82)	3.50 ±0.37 *	5.64 ±0.90 *	7.24 ±1.64 *	6.64 ±2.76 *	5.32 ±1.54 *	5.04 ±1.46 *	8.84 ±2.44 *	6.77 ±1.60 *	9.31 ±3.65 **	57.57 ±10.63 *

Values are mean ± SD

* $p < 0.001$, ** $p < 0.01$ (When compared by ANOVA)

Table 3 Girths and widths of the subjects

Category	GIRTHS (cm)			WIDTHS (cm)	
	(i) Arm	(ii) Calf	Sum (i+ii)	Bi-Humerus	Bi-Femur
Sedentary (N=50)	26.54 ±3.26	35.54 ±2.46	62.08 ±4.80	6.20 ±0.52	9.84 ±0.64
Soccer (N=46)	25.07 ±1.62	33.06 ±1.51 *	58.15 ±2.82 *	6.26 ±0.31	9.89 ±0.60
Volleyball (N=82)	24.47 ±3.41	32.20 ±2.51 *	56.41 ±5.40 *	6.36 ±0.39	9.94 ±0.90

Values are mean±SD, * $p<0.001$ (When compared by ANOVA)

Table 4 Different components of body composition of the subjects

Category	BD (gm/cc)	% fat	TBF (kg)	% LBM	LBM (kg)
Sedentary (N=50)	1.061 ±0.008	16.70 ±3.55	9.29 ±2.41	83.30 ±3.55	46.19 ±4.95
Soccer (N=46)	1.076 ±0.008 *	10.03 ±3.43 *	5.75 ±2.67 *	89.97 ±3.43 *	50.32 ±6.33 **
Volleyball (N=82)	1.076 ±0.007 *	10.04 ±2.98 *	6.00 ±2.18 *	89.96 ±2.98 *	52.86 ±5.63 *

Values are mean±SD

* $p<.001$, ** $p<0.01$ (When compared by ANOVA)

Fig. 1 Somatotype scores of sedentary individuals and sportspersons.

Discussion

The body height was significantly higher ($p<0.001$) among the volleyball players. But significantly higher body mass

($p<0.001$) among volleyball players may be a hurdle for them in attaining a good jumping height because they have to lift a greater weight as a result of having a higher body mass. The lower body height and proportionately higher body mass of volleyball players than their international counterparts (Duncan et al., 2006; Guialdi and Zaccagni, 2001; Calbet et al., 1999) are disadvantages for them because shorter height and greater body mass will prevent them from achieving the sort of jumping height that is crucial for this game.

Lower values of body height and body mass among the footballers than their international counterparts (Silvestre et al., 2006; Diaz et al., 2003; Rico-Sanz et al., 1998; Florida and Reilly, 1995; Chin et al., 1992) are also drawbacks for them. Due to lower body height they are unable to achieve the sort of jumping height required for optimal heading of the ball. Moreover, due to lower body mass they are unable to withstand the greater momentum produced by the higher body mass of their opponents as projected during body contact.

All the skinfolds and calf girths are significantly higher in the sedentary group, indicating that the sedentary population has a greater quantity of subcutaneous fat deposition, which was also reflected in their significantly higher ($p<0.001$) value of %fat than the sportspersons. However, the LBM is significantly higher among the sportspersons.

The present data of %fat accords with the proposal that %fat value among soccer and volleyball players should be within the range of 6–14% and 6–15%, respectively (Wilmore and Costill, 1999). Rico-Sanz (1998) stated in his review work that footballers should have a body fat percentage of around 10% and this is in agreement with the finding of the present study. The footballers of California and Hongkong have lower values of %fat (Rico-Sanz, 1998; Chin et al., 1992), whereas higher %fat values have been reported in their counterparts from the UK, the USA, and Spain (Florida and Reilly, 1995; Silvestre et al., 2006; Diaz et al., 2003). But the reports depicted higher LBM than the Indian footballers, probably because of higher body mass among the overseas players, who will therefore achieve better performance since the more the LBM the greater will be the energy output and the higher will be the cardiorespiratory fitness (Bandyopadhyay and Chatterjee, 2003; Chatterjee et al., 2005). Conversely, the greater fat content in the Indian footballers will act as a hindrance in their performance (Bandyopadhyay and Chatterjee, 2003; Chatterjee et al., 2005).

The work-rate profile of a player depends on the type of competition and playing position, which are highly correlated with the anthropometric contour and somatotype scores (Rienzi et al., 2000). In the present study, somatotyping (Fig. 1) revealed a general finding, i.e., significantly higher endomorphic and significantly lower mesomorphic scores among the sedentary individuals, and the sportspersons were found to be mesomorphic ectomorph (McArdle et al., 1986; Toriola et al., 1985). The mesomorphic score is significantly ($p<0.001$) higher among the volleyball and soccer players whereas the ectomorphy is significantly higher ($p<0.001$) in

the volleyball group only. This finding agreed with previous studies (Duncan et al., 2006; Gualdi and Zaccagni, 2001; Florida and Reilly, 1995). Skinfolds, girth measurements, body composition, and somatotyping indicated that excess fatness existed among the sedentary individuals, probably because their regular working activity is much less. Reports indicated that a mild to vigorous training program, such as that of sportspersons, significantly reduces the fat weight (Duthi et al., 2006; Chatterjee et al., 2002).

Prediction equations for %fat from BMI were computed as these two parameters were found to be significantly ($p < 0.001$) correlated.

Sedentary Subjects: $Y = 1.494X - 13.673$, $r = 0.72$,
SEE = 2.46

Soccer Players: $Y = 1.561X - 22.064$, $r = 0.86$,
SEE = 1.75

Volleyball Players: $Y = 1.746X - 24.164$,
 $r = 0.92$, SEE = 1.17

The ectomorphic, mesomorphic, and endomorphic scores of the soccer players are higher than their counterparts from the Liverpool, Russian, and South American international teams (Florida and Reilly, 1995; Martirosov et al., 1987; Rienzi et al., 2000). Rienzi et al. (2000) reported that South American international soccer players are balanced mesomorph (2–5.5–2) which agrees with the present finding and previous studies on soccer players in the UK, Russia, and Indonesia (Florida and Reilly, 1995; Martirosov et al., 1987; Neni et al., 2006). The somatotype of leading footballers from Russia was reported as 1.7–5.6–2.6 whereas their counterparts from Liverpool had a mean somatotype of 2.4–4.2–2.4 (Martirosov et al., 1987; Florida and Reilly, 1995). On the other hand, Indonesian soccer players exhibited a somatotype score of 2.7–4.9–3.0 (Neni et al., 2006). Studies of Nigerian soccer players (Salokun, 1994) suggested that 45% of the meso-ectomorphs and 44% of the mesomorphs sustained injuries, while 85% of the ectomorphs and 50% of the ecto-mesomorphs were injured. The study therefore recommended that selection of soccer players according to somatotype profile helps to lower the injury rate, and that mainly mesomorphs and to some extent meso-ectomorphic types should ultimately be considered as prospective soccer players.

The somatotype of volleyball players alters with their positional variation at different levels of performance (e.g., state, national, or international) depending on the technical and tactical demands placed on the players (Duncan et al., 2006; Gualdi and Zaccagni, 2001). The junior elite volleyball players of the UK exhibited more ectomorphic and less mesomorphic scores among setters than centers. Their mean (SD) somatotype scores for setters and centers were 2.6(0.9)–1.9(1.1)–5.3(1.2) and 2.2(0.8)–3.9(1.1)–3.6(0.7), respectively (Duncan et al., 2006). Italian male volleyball players had somatotype scores of 2.4(0.7)–4.5(0.9)–2.8(0.8) for setters, 2.0(0.6)–4.0(1.0)–3.5(0.8) for centers, 2.2(0.6)–4.3(0.9)–3.0(0.7) for spikers and 2.2(0.6)–4.3(0.9)–3.1(0.8) for opposites. Indonesian volleyball players exhibited the mesomorphic-ectomorph somatotype,

with a somatotype score of 2.4–3.5–3.7 (Neni et al., 2006), which contradicts the present and other findings with the ectomorphic-mesomorph somatotypes of volleyball players (Duncan et al., 2006; Gualdi and Zaccagni, 2001). However, the volleyball players from West Bengal, India have higher somatotype scores than their counterparts from the UK, Italy, and Indonesia. This observation once more reflects the idea that the Indian volleyball players are heavier than their overseas counterparts and this may further hinder their performance at international tournaments. But greater ectomorphic and mesomorphic scores may be advantageous for them because of the nature of the game played in volleyball, where centers require endurance to oppose the attack, while setters need more speed and agility to organize the attack (Duncan et al., 2006).

The observations in the present investigation reflected higher fatness among sedentary individuals than sportspersons, though BMI had insignificant variation. However, the present data will serve as a reference standard for the anthropometry and body composition of Indian soccer and volleyball players. Moreover, as the determination of body composition is hazardous because of its complicated protocol, the prediction norms for %fat from BMI can be recommended to obtain a first-hand impression about the body composition in the studied population. However, specific positional roles in soccer and volleyball require distinct technical skills and therefore further research is essential to detect whether the positional variation of Indian soccer and volleyball players relates to any difference in their morphological characteristics.

References

- Bandyopadhyay A, Chatterjee S (2003) Body composition, morphological characteristics and their relationship with cardiorespiratory fitness. *Ergonomics* 15: 19–27
- Bouchard C, Lortie G (1984) Heredity and endurance performance. *Sport Med* 1: 38–64
- Calbet JA, Diaz HP, Rodriguez LP (1999) High bone mineral density in male elite professional volleyball players. *Osteoporos Int* 10: 468–474
- Chatterjee P, Chatterjee S, Mukherjee PS, Bandyopadhyay A (2002) Evaluation and inter-relationship of body mass index, percentage of body fat, skinfolds and girth measurements in boys of 10–16 years. *Biomedicine* 22: 9–16
- Chatterjee S, Chatterjee P, Bandyopadhyay A (2005) Cardiorespiratory fitness of obese boys. *Indian J Physiol Pharmacol* 49: 353–357
- Chatterjee S, Chatterjee P, Bandyopadhyay A (2006) Skinfold thickness, body fat percentage and body mass index in obese and non-obese Indian boys. *Asia Pac J Clin Nutr* 15: 232–235
- Chin MK, Lo YS, Li CT, So CH (1992) Physiological profiles of Hong Kong elite soccer players. *Br J Sports Med* 26: 262–266
- Diaz FJ, Montano JG, Melchor MT, Garcia MR, Guerrero JH,

- Rivera AE, Tovar JA, Moreno MF (2006) Changes of physical and functional characteristics in soccer players. *Rev Invest Clin* 55: 528–534
- DuBois D, DuBois EF (1916) A formula to estimate approximate body surface area if height and weight be known. *Arch Int Med* 17: 863
- Duncan MJ, Woodfield L, al-Nakeeb Y. (2006) Anthropometric and physiological characteristics of junior elite volleyball players. *Br J Sports Med* 40: 649–651
- Duthie DB, Pyne WG, Hopkins S, Livingstone SL, Hooper GM (2006) Anthropometry profiles of elite rugby players: quantifying changes in lean mass. *Br J Sports Med* 40: 202–207
- Fagard R, Bielen E, Amery A (1991) Heritability of aerobic power and anaerobic energy generation during exercise. *J Appl Physiol* 70: 357–362
- Florida-James G, Reilly T (1995) The physiological demands of Gaelic football. *Br J Sports Med* 29: 41–45
- Gualdi-Russo E, Zaccagni L (2001) Somatotype, role and performance in elite volleyball player. *J Sports Med Phys Fitness* 41: 256–262
- Jackson AS, Pollock ML (1978) Generalized equations for predicting body density of men. *Br J Nutr* 40: 497–504
- Johnson BL, Nelson JK (1982) Practical measurement for evaluation in physical education. Surjeet Publication, Delhi-India, 165–167
- Keogh J (1999) The use of physical fitness scores and anthropometric data to predict selection in an elite under-18 Australian rules football team. *J Sci Med Sport* 2: 125–133
- Martirosov EG, Skhomorokov EV, Farmochi I, Varga Sh (1987) Somatotypes of the world's leading football players. *Arkh Anat Gistol Embriol* 93: 29–33
- McArdle WD, Katch FI, Katch VL (1986) Exercise Physiology, Energy, Nutrition and Human Performance. Lea and Febiger, Philadelphia, 539–574
- Meltzer A, Mueller W, Annegers J, Grimes B, Albright D (1988) Weight history and hypertension. *J Clin Epidemiol* 41: 867–874
- Neni TR, Santosa B, Kumi A (2006) Somatotypes of young male athlete and non-athlete students in Yogyakarta, Indonesia. *Anthropol Sci: Online* at [www.jstage.jst.go.jp:DOI 10.1537/ase.051008](http://www.jstage.jst.go.jp:DOI/10.1537/ase.051008)
- Rico-Sanz J (1998) Body composition and nutritional assessments in soccer. *Int J Sport Nutr* 8: 113–123
- Rico-Sanz J, Frontera WR, Mole PA, Rivera MA, Rivera-Brown A, Meredith CN (1998) Dietary and performance assessment of elite soccer players during a period of intense training. *Int J Sport Nutr* 8: 230–240
- Rienzi E, Drust B, Reilly T, Carter JE, Martin A (2000) Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *J Sports Med Phys Fitness* 40: 162–169
- Salokun SO (1994) Minimizing injury rates in soccer through preselection of players by somatotypes. *J Sports Med Phys Fitness* 34: 64–69
- Silvestre R, West C, Maresh CM, Kraemer WJ (2006) Body composition and physical performance in men's soccer: a study of a National Collegiate Athletic Association Division I team. *J Strength Cond Res* 20: 177–183
- Siri WE (1956) The gross composition of the body. *Adv Biol Med Phys* 4: 256–280
- Toriola AL, Salokun SO, Mathur DN (1985) Somatotype characteristics of male sprinters, basketball, soccer, and field hockey players. *Int J Sports Med* 6: 344–350
- Wilmore JH, Costill DL (1999) Physiology of Sports and Exercise. 2nd ed. Human Kinetics, Champaign, 490–507

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