Somatotypes of young male athletes and non-athlete students in Yogyakarta, Indonesia

Neni Trilusiana RAHMAWATI¹, Santosa BUDIHARJO¹, Kumi ASHIZAWA²*

¹Laboratory of Anatomy and Anthropology, School of Medicine Gadjah Mada University, Yogyakarta, Indonesia
²Institute of Human Living Sciences, Otsuma Women’s University, Sanban-cho 12, Chiyoda-ku, Tokyo, 102-8357 Japan

Received 8 October 2005; accepted 28 March 2006

Abstract There is a considerable corpus of evidence indicating that athletes succeeding in certain sports have distinctive body shapes that differ according to the demands of the type of sports and competitive level. The aim of this study was to determine the specific morphological characteristics of young male athletes compared with non-athlete students in Indonesia. Anthropometric measurements of 19 badminton players, 96 soccer players, 74 volleyball players, and 51 non-athlete undergraduate students, aged 16 to 28, were obtained in 1994 and 1995. Stature, body weight, bicondylar breadths of the humerus and femur, calf and upper arm circumferences, and skinfolds (at triceps, subscapula, calf, and supraspine) were measured for each subject. Heath-Carter somatotypes were determined in all the subjects. The results of the ANOVA of the body measurements showed that the three groups of athletes and the non-athlete students were heterogeneous: the badminton players were shorter and lighter with greater skinfold values among the athlete groups; the soccer players were relatively shorter and with smaller skinfold values and greater arm and leg girths; and the volleyball players were taller and heavier with smaller elbow and knee breadths and very small skinfold values. The non-athlete students were characterized by greater arm girth, elbow breadths, knee breadths, and back and leg skinfolds. In mean somatotype category, the badminton players were ‘central’ (3.3-3.7-3.7), the soccer players were ‘balanced mesomorph’ (2.7-4.9-3.0), the volleyball players were ‘mesomorph-ectomorph’ (2.4-3.5-3.7), and the non-athlete students were ‘ectomorphic mesomorph’ (2.7-5.2-3.8). Comparisons of international scope with each of the different sports showed that the Indonesian players were extremely short and light.

Key words: somatotype, Javanese, youth, athletes, non-athlete students

Introduction

Sports scientists and human biologists have paid much attention to the relationships between physical characteristics and performance in sports. Many studies based on anthropometry have concluded that the morphological characteristics of athletes successful in a specific sport are biased in comparison with ordinary non-athletes, among type of sports and among levels within a sport (de Garay et al., 1974). According to Carter and Heath (1990), more than 100 studies have been published in the past 15 years, and 14 books have reported studies of Olympic athletes. One method of describing morphological characteristics is somatotyping, in which body shape, rather than size, is expressed by a three-number rating that represents the components of endomorphy (fatness), mesomorphy (musculoskeletal development) and ectomorphy (linearity) (Sheldon, 1940, 1954). It is now established that outstanding athletes and people in sports differ significantly in their physical and physiological characteristics, corresponding, to some extent, with the particular requirements of their respective events (Piscopo and Baley, 1981; Kansal et al., 1986; Carter and Heath, 1990). On the web site ‘Somatotype Bibliography II (1991 to April 2003)’ (www.somatotype.org/bibliography. php), we found 179 references, including master’s theses and conference proceedings. Many of these publications are in Spanish, and/or are studies reported in physical fitness and sports medicine journals. In the major anthropology and human biology journals, such as the Annals of Human Biology, the American Journal of Human Biology, the American Journal of Physical Anthropology, and Anthropological Science, there have been few studies since 1990 concerning somatotypes.

According to Carter and his colleagues (Carter, 1968; Carter and Heath 1990), football players of the National Football League and San Diego State University were endomesomorphic, with mean somatotypes of approximately 4.5-6.5-1.5 and 4.6-6.3-1.4, respectively. The USA national volleyball team of 1985 was less endomorphic and mesomorphic, and more ectomorphic than the 1975 team, while soccer players from five countries in the South American Youth Championship had a mean somatotype of 3.6-3.6-2.5 or endomorphic-ectomorphic. Very few definitive studies have been made on the somatotypes of athletes in Asia, except in Japan. Since there are

* Corresponding author. e-mail: akumi@otsuma.ac.jp
phone: +81-3-5275-6043; fax: +81-3-3264-6977
Published online 8 August 2006
in J-STAGE (www.jstage.jst.go.jp) DOI: 10.1537/ase.051008

© 2006 The Anthropological Society of Nippon
Subjects and Methods

The subjects were all males, numbering 19 badminton players (aged 16 to 27), 96 soccer players (aged 16 to 28), 74 volleyball players (aged 16 to 28); 51 medical students (aged 17 to 21) served as a control group. The subjects were measured in Yogyakarta in 1994 and 1995. The athletes were both professionals and amateurs; the former were from famous local-level teams but not national league members. The average age of the control student group was younger than the athletes, and this may imply that their growth was incomplete. Since these controls were medical students, the indication is that they were from well-off families.

The following 10 body measurements were obtained for each subject employing the method described in Carter and Heath (1990): stature, body weight, bicondylar breadths of the humerus and femur, calf and upper arm circumferences, and triceps, subscapular, calf, and supraspinal skinfolds. Stature was measured to the nearest 1 mm with an anthropometer, body weight with minimal clothing was recorded to the nearest 0.05 kg employing a weighing scale, and skinfolds were obtained using a Holtain caliper with a constant pressure of 10 g/mm. Outlier subjects in each group with a measurement value greater than 3 standard deviations (SD) from the mean were deleted. After the mean values and standard deviations were obtained for the final data set, the somatotype components of the individual subjects were calculated according to the Heath–Carter method, using the following equations (Carter, 1980; Carter and Heath, 1990):

$$\text{Endomorphy} = -0.7182 + 0.1415(X - 0.00068(X^2)) + 0.000014(X^3)$$

$$\text{Mesomorphy} = [(0.858 \times \text{humerus breadth}) + (0.601 \times \text{femur breadth}) + (0.188 \times \text{corrected arm girth}) + (0.161 \times \text{corrected calf girth})] - (\text{height} \times 0.131) + 4.50$$

$$\text{Ectomorphy} = \text{HWR} \times 0.732 - 28.58 \text{ (if HWR} \geq 40.75)$$

$$\text{ectomorphy} = \text{HWR} \times 0.463 - 17.63 \text{ (if 40.75} > \text{HWR} > 38.25)$$

$$\text{ectomorphy} = 0.1 \text{ (if 38.25} \geq \text{HWR})$$

$$\text{HWR} = \text{height}/(\text{cube root of weight}).$$

The somatotype of each subject was plotted on the Carter somatocart after calculating the $X$ and $Y$ coordinate values using the following formula (Carter and Heath, 1990): $X = \text{ectomorphy} - \text{endomorphy}$; $Y = 2 \times \text{mesomorphy} - \text{(endomorphy} + \text{ectomorphy})$.

Authors N.T.R and S.B. measured the subjects, and K.A. analysed the data. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS), version 10 for Macintosh.

Results

The mean and SD values of the body measurements are given in Table 1. To normalize the distribution, skinfolds were transformed using the following formula (Tanner, 1962): $Z = 100 \log_{10}(X - 18)$, where $X$ is the skinfold reading in 0.1 mm. The transformed skinfolds are indicated with the prefix ‘Z-’. One-way ANOVA of the measurements among the three groups of athletes and the group of students revealed a highly significant difference except with the Z-supraspinal skinfold (femur breadth, 0.05 $>$ $P$ $>$ 0.01; the others, 0.001 $>$ $P$). Among the three athlete groups no statistical difference was detected in femur breadth and Z-supraspinal and Z-medial calf skinfolds; the other measurements were significantly different (humerus breadth, 0.05 $>$ $P$ $>$ 0.01; Z-subscapular skinfold, 0.001 $>$ $P$). Body mass index (BMI) was defined as weight (kg)/stature$^2$ (m$^2$).

The mean and SD values of each somatocore are presented in Table 2. A normal distribution was obtained only

<table>
<thead>
<tr>
<th>Table 1. Mean and standard deviation values of the body measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yrs)</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td><strong>n</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td><strong>Stature (cm)</strong></td>
</tr>
<tr>
<td><strong>Upper arm girth (cm)</strong></td>
</tr>
<tr>
<td><strong>Calf girth (cm)</strong></td>
</tr>
<tr>
<td><strong>Humerus breadth (cm)</strong></td>
</tr>
<tr>
<td><strong>Femur breadth (cm)</strong></td>
</tr>
<tr>
<td><strong>Triceps skinfolds (mm)</strong></td>
</tr>
<tr>
<td><strong>Z-Triceps (0.1 mm)</strong></td>
</tr>
<tr>
<td><strong>Subscapular skinfolds (mm)</strong></td>
</tr>
<tr>
<td><strong>Z-Subscapular (0.1 mm)</strong></td>
</tr>
<tr>
<td><strong>Supraspinal skinfolds (mm)</strong></td>
</tr>
<tr>
<td><strong>Z-Supraspinal (0.1 mm)</strong></td>
</tr>
<tr>
<td><strong>Medial calf skinfolds (mm)</strong></td>
</tr>
<tr>
<td><strong>Z-Medial calf (0.1 mm)</strong></td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
</tr>
<tr>
<td><strong>BMI</strong></td>
</tr>
</tbody>
</table>
with the endomorphic score of the soccer (0.01 > P > 0.001) and student (0.001 > P > 0.0001) groups. The Kruskal–Wallis test of the somatotypes indicated that all the somatotypes were significantly different among the four groups (endomorphic score, 0.01 > P > 0.001; mesomorphic and ectomorphic scores, 0.001 > P).

In brief, the badminton, soccer, and volleyball players, and the non-athlete students were heterogeneous with respect to both anthropometric characteristics and the somatotypes.

Discussion

Anthropometric characteristics

A normal distribution was obtained in all four groups, only with stature, calf girth, and BMI. Comparisons of each measurement are illustrated in Figure 1. The difference between each pair of groups (multiple comparisons) was tested by means of the Tukey HSD and Scheffé’s tests for the measurements with normal and non-normal distributions, respectively.

From Figure 1 it can be seen that there was no statistical difference in the femur breadth and Z-supraspinal skinfold between any of the group pairs. The badminton players were distinguished by shortness, lightness, low BMI, and thinness and narrowness of the four limbs, but in contrast to these characteristics, also by the largest Z-triceps skinfold value. In short, the badminton players were small but their upper arm and trunk skinfolds were relatively great. The soccer players were characterized by large girths of the four limbs and a large BMI, but their elbow and knee breadths, and skinfolds. The medical students exhibited medium stature, weight, and a large BMI, but their elbow and knee breadths and Z-subscapular and Z-medial calf skinfolds were remarkably smaller than in the medical students. The volleyball players were taller and had greater weight, but their upper arm girth and BMI were relatively less endomorphic and ectomorphic, but more mesomorphic. The volleyball players were less endomorphic and mesomorphic but more ectomorphic than the soccer players and about the same as the badminton players and students. The students were less endomorphic than the badminton players, but more mesomorphic than the badminton and volleyball players, and more ectomorphic than the soccer players. In other words, the badminton players were relatively balanced in the three components; the soccer players were characterized by a dominant mesomorphic component; the volleyball players were characterized by a relatively weaker endomorphic component; and the medical students were characterized by a dominant mesomorphic component as with the soccer players, but with a more ectomorphic component.

The somatotype of each subject was designated according to the Carter somatototype (Figure 3). In this figure, we observe first that the distributions of the badminton players and students extend to all the sectors except the ectomorphic endomorph sector, and that the scatter is relatively more concentrated in the badminton players than in the students. Second, we observe that the somatotype distributions of the soccer and volleyball players were biased, i.e. with few falling into the ectomorphic endomorph sector, many of the soccer players were rather mesomorphic, but the volleyball players tended to be more ectomorphic.

Since these scattergrams indicate that the somatotype distributions differ according to the type of sports, each subject was classified into one of the Carter somatotype categories (Carter and Heath, 1990: p. 406). We noticed that the distribution of the subjects was distinctive according to the type of sports; in brief, the soccer players and non-athlete students were mesomorphic, the volleyball players were ectomorphic, and the badminton players were central. The category ‘central’ appeared most frequently in the badminton players (6/19 or 32%), followed by the category ‘balanced ectomorph’ (3/19 or 16%). More than half of the soccer players were ‘endomorphic mesomorph’ or ‘ectomorphic mesomorph’ (29/96 or 30% and 27/96 or 28%, respectively). Among the volleyball players nearly half of the subjects were ‘mesomorphic ectomorph’ (30/74 or 41%), followed by ‘central’ (12/74 or 16%). Among the non-athlete students the most frequent category was ‘ectomorphic mesomorph’ (18/51 or 35.3%), followed by ‘endomorphic mesomorph’ (9/51 or 18%). The Pearson chi-square tests indicated that there were significant relationships between type of sports and somatotype categories.

Somatotypes

The mean somatotype of the badminton players was 3.3-3.7-3.7, that of the soccer players 2.7-4.9-3.0, that of the volleyball players 2.4-3.5-3.7, and that of the medical students 2.7-5.2-3.8 (see Table 2). A comparison of the scores between each pair of groups (multiple comparisons) is illustrated in Figure 2 together with the results of Scheffé’s non-parametric test because a normal distribution had not been assured in all the somatotypes. We observe that the badminton players have the highest endomorphic score among the groups and a low mesomorphic score. The soccer players were relatively less endomorphic and ectomorphic, but more mesomorphic. The volleyball players were less endomorphic and mesomorphic but more ectomorphic than the soccer players and about the same as the badminton players and students. The students were less endomorphic than the badminton players, but more mesomorphic than the badminton and volleyball players, and more ectomorphic than the soccer players. In other words, the badminton players were relatively balanced in the three components; the soccer players were characterized by a dominant mesomorphic component; the volleyball players were characterized by a relatively weaker endomorphic component; and the medical students were characterized by a dominant mesomorphic component as with the soccer players, but with a more ectomorphic component.

Table 2. Mean and standard deviation values of somatotypes

<table>
<thead>
<tr>
<th></th>
<th>Badminton</th>
<th>Soccer</th>
<th>Volleyball</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>19</td>
<td>96</td>
<td>74</td>
<td>51</td>
</tr>
<tr>
<td>Endomorphic</td>
<td>3.29</td>
<td>2.70</td>
<td>2.39</td>
<td>2.71</td>
</tr>
<tr>
<td>Mesomorphic</td>
<td>0.76</td>
<td>1.12</td>
<td>1.07</td>
<td>1.36</td>
</tr>
<tr>
<td>Ectomorphic</td>
<td>3.70</td>
<td>4.94</td>
<td>3.50</td>
<td>5.20</td>
</tr>
</tbody>
</table>

Table 2. Mean and standard deviation values of somatotypes
Figure 1. Comparison of each measurement and results of the Tukey HSD or Scheffé’s tests (*, $0.05 > P > 0.01$; **, $0.01 > P > 0.001$; ***, $0.001 > P$).
Figure 2. Comparison of each somatoscore and non-parametric test results (*, $0.05 > P > 0.01$; **, $0.01 > P > 0.001$; ***, $0.001 > P$).

Figure 3. Somatotype distributions of subjects in each sport and of the non-athlete students.
Somatotypes of each type of sports: international comparisons

In the literature (Carter and Heath, 1990) we found somatotype descriptions of badminton, soccer and volleyball players from all over the world. Using the mean somatotypes cited in that literature, we calculated the X and Y coordinates and depicted the distribution of the mean somatotypes on the Carter somatochart (Figure 4). We then compared these with plots of the mean somatotypes of the Indonesian players and students.

Badminton players

Only one reference for badminton players was available, giving information on the South Australian somatotype (see Carter and Heath, 1990). However, the sample number was very small: 7 subjects with a mean age of 24.5, on average 20 cm higher and 22.5 kg heavier than the Indonesian badminton players (P < 0.001 for both height and weight).

In contrast to the Indonesian badminton players, whose mean somatotype was 3.3-3.7-3.7, which falls into the ‘central’ somatotype category, the South Australian players were more mesomorphic by more than one unit with a mean somatotype of 2.5-4.6-3.2, thus falling into the category ‘ectomorphic mesomorph’. We observe in Figure 4 that the somatotypes of the Indonesian medical students were distributed very closely to that of the South Australian badminton players rather than to the Indonesian players.

Soccer players

Seven soccer player reference groups were available for comparison with the Indonesian soccer players, as determined by the mean age of the subjects: Bratislava, South Australia, Nigeria, two series from Brazil, Cuba, and Bolivians in Caracas (see Carter and Heath, 1990).

The mean height and weight of these groups of players ranged from 169 to 178 cm and 69 to 75 kg, whereas those of the Indonesians were 166 cm and 58 kg. Compared with the smallest group among the references, the Indonesian group was 3 cm shorter than the players in the Bolivar Games (0.01 < P < 0.05), and 7 kg lighter than the players in Nigeria (P < 0.001).

The mean somatotype of the Indonesian players was 2.7-4.9-3.0, thus falling within the category ‘balanced mesomorph’. They did not differ greatly from the players of other countries: i.e. players in Brazil were reported as ‘endomorphic mesomorph’ and the Bolivians in Caracas as ‘ectomorphic mesomorph’, but the others were all ‘balanced mesomorph’, the same as the Indonesian players. Figure 4 indicates that all the groups, including the Indonesian students, were relatively well concentrated.

Volleyball players

Eight referenced players [Venezuela, Bolivar Games, Cuba, South Australia, National, Camp and State groups in India, and 1983 USA Olympic athletes (see Carter and Heath, 1990)], with a mean age of 20 to 26 years old, were compared with the Indonesian players. The mean height and weight of the reference groups were 179 to 194 cm and 66 to 88 kg, respectively, while for the Indonesian players the means were 173 cm and 61 kg, respectively, i.e. 6 cm and 5 kg smaller than the smallest group among the references, namely the State players in India (P < 0.001 for both height and weight).

Carter and Heath (1990) pointed out that there was a large range of somatotype distribution in volleyball players, and that the majority of somatotypes were ecto-mesomorphic but ranging from endo-mesomorphy to meso-ectomorphy. Except for the two groups, the National and State players in India, who exhibited the somatotype category ‘mesomorphic ectomorph’, the other groups of players, including the Indonesian, exhibited the category ‘ectomorphic mesomorph’. In the Carter somatochart (Figure 4), however, a larger Y axis range was observed in these volleyball groups, but the X axis range was smaller than in the soccer groups. This observation seems to contradict the results of Carter and Heath (1990).

In brief, we remark on two points comparing the Indonesian athletes and students with the athletes of the other countries. The first point is that the Indonesian athletes were much shorter and lighter than the other athletes. Concerning this point, we can presume that the normal non-athlete Indonesian population is significantly smaller than normal non-athlete Australians, Nigerians, South and Central Americans, and Indians, although hardly any anthropometric data

![Figure 4. Comparison of international badminton, soccer, and volleyball players, including Indonesian players and students.](image-url)
are available especially for non-athlete Indonesian adults. In this case, even if the subjects had been national league players, the shortness and lightness of the Indonesian athlete subjects could be reasonably expected, and attributable to genetic and/or so-called racial differences. The second point is that the Indonesian students were rather closer to the international athlete groups than to the Indonesian athlete groups. The likely reason for this could be the socioeconomic difference between the families of the local-level athletes and medical students, although, in this case again, hardly any concrete evidence is currently available.

**Conclusions**

This paper is the first study of adult Indonesian somatotypes, and in particular of male athletes in Indonesia. The subjects were badminton, soccer, and volleyball players aged in their 20s. Non-athlete undergraduate students were also studied as a control group. The following findings were obtained:

The results of ANOVA and the Kruskal–Wallis test showed that these groups were heterogeneous: i.e. the badminton players were small in height and weight, but their upper arm and trunk skinfolds were relatively great; the soccer players exhibited great girth in all four limbs and a large BMI value, but their limb breadths and back and leg skinfolds were smaller than those of the non-athlete students; the volleyball players were greater in stature and weight, but smaller in skinfolds and limb girths and breadths. The students were medium in stature, weight, and BMI, but they had greater skinfold on the legs.

The mean somatotype of the badminton players was ‘central’ (3.3-3.7-3.7), that of the soccer players was ‘balanced mesomorph’ (2.7-4.9-3.0), that of the volleyball players was ‘mesomorphic ectomorph’ (2.4-3.5-3.7), and that of the students were ‘ectomorphic mesomorph’ (2.7-5.2-3.8).

Compared with international data, the Indonesian players were found to be extremely short and light in each of the sports.

The mean somatotype of the Indonesian badminton players was ‘central’, contrasting with the more mesomorphic South Australian players. The mean somatotype of the Indonesian soccer players was ‘balanced mesomorph’, and thus incorporated into the distribution of mean somatotypes of the other countries. The somatotypes of the international volleyball groups were divided into ‘mesomorphic ectomorph’ and ‘ectomorphic mesomorph’, with the latter incorporating the Indonesian players.

**Acknowledgments**

The authors would like to thank Professor T. Jacob for his suggestion. We would like to express our heartfelt thanks to the director of the Gadjah Mada Sport Study Center, the athletes of soccer, volleyball, and badminton, and the medical students of the Gadjah Mada University, Jogjakarta, Indonesia.

**References**


__Erratum:__

Page 2, left column, last two lines.
Now reads:
“where $X = \text{triceps skinfold} + \text{subscapular skinfold} + \text{supraspinale skinfold}$”
Should read:
“where $X = (\text{triceps skinfold} + \text{subscapular skinfold} + \text{supraspinale skinfold}) \times 170.18/\text{height in cm}$”