Original Article

Somatotypes of Young Malaysian Track and Field Athletes

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The purpose of this study was to describe the somatotype of 95 young track and field athletes (58 males, 37 females) aged 17.7±1.7 years competing at the 2006 Malaysian Games. Each athlete completed an anthropometric battery of tests (7 skinfolds, 2 girths and 2 breadths) undertaken by trained anthropometrists using standard protocols (ISAK). Somatotype was derived using the Heath-Carter somatotype scale.

The male athletes were mesomorphs (2.7-5.2-2.8), while the female athletes were endomorph-mesomorph (3.9-4.4-2.7). Somatotypes for male throw, jump, sprint, distance and hurdle athletes were 5.9-7.5-0.7, 2.0-4.5-3.4, 2.1-5.1-2.9, 2.2-4.2-3.7 and 1.9-4.7-3.4 respectively. For female athletes, mean somatotype for throw, jump, sprint, distance and hurdle athletes were 6.6-7.2-0.6, 3.3-3.0-3.6, 3.0-3.7-3.2, 2.7-2.9-4.4 and 3.2-4.2-2.9, respectively. Significant differences in mean somatotypes for male (P=0.001, _2=0.33) and female (P<0.001, _2=0.44) athletes and their three components (P<0.001) were found among the five groups. When compared to adult Olympic and young Brazilian student athletes, the Malaysian athletes had similar somatotypes, apart from the throw groups being more endomorphic. These results provide the first description of the somatotype of young Malaysian track and field athletes.
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Introduction

Somatotyping of athletes has been completed for many sports at an international level (Ackland et at., 2003; Bloomfield et al., 1994; Carter et al., 2005). Somatotype was first derived by Sheldon et al. (1940), further developed by Parnell (1958) and refined by Heath and Carter (1967). As an objective assessment of body shape and composition, independent of size, somatotype describes the human physique using three numbers, which denote the amounts of adiposity (endomorphy), muscularity (mesomorphy) and slenderness (ectomorphy). Thus, somatoyping is believed to provide a better descriptive picture of physical characteristics than simple linear anthropometric measurements.

In the field of sports science, somatotype is often used as an indicator of whether the athlete has a physique suitable for performance at a high level. Somatotyping has been related to elite performance primarily in adults (Bayios et al., 2006; Battinelli, 2000; Gualdi-Russo & Zaccagni, 2001) but in only a limited number of studies of adolescents (Claessens et al., 1999). Physique has been identified to play an important role in both the self-selection process and talent identification for various sports and events (Reilly et al., 2000; Bloomfield et al., 1994).

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To date, there is very little information on the somatotype of young track and field athletes. Is the somatotype of young athletes similar to that of their elite counterparts? In addition, as there is limited information on Asian athletes and Malaysian athletes in particular, it is timely for this information to be collected and published.

The purpose of this study was to describe the somatotype of young track and field athletes during the 2006 Malaysian Games (SUKMA Kedah). In addition the results of this study will be compared to previously published somatotype data for track and field athletes.

Methods

Permission to undertake this study was granted by the National Sports Council of Malaysia and the Sukan Malaysia Secretariat. These data were obtained as part of the Malaysian Games Anthropometry Project 2006 (MGAP06). A written consent form was completed by all subjects.

Sample

The sample consisted of track and field athletes participating in the 11th Malaysian Games, SUKMA Kedah held in June 2006. These Malaysian Games include the best young athletes from throughout Malaysia. All track and field athletes were invited to participate in the testing program. However, because of the competition schedule, only 108 athletes (68 male, 40 female) from five states were able to complete the tests. The sample consisted of 66 Malays (61%), 17 Indians

(16%), 13 Chinese (12%) and 11 indigenous people (11%). These 108 athletes represented 23% of the track and field athletes competing, of which 14% were medallists.

Equipment

Body mass and stature measurements were performed on the SECA (Model 767) electronic personal scale with accuracy of 100g and 0.1cm respectively. Skinfold thickness was assessed using the Harpenden skinfold calliper (HSK-BI, British Indicators) with 0.20mm accuracy. Girths was measured using anthropometric tape of 1mm accuracy scale (W606PM, Lufkin), and breadths with a 1mm accuracy small sliding calliper (Tommy 3, Rosscraft).

Testing protocol

Data were collected at the Games Village (Universiti Utara Malaysia) during the competition period. Personal details were obtained at the first test station (A) before moving to the second station (B) for weight and stature measurements. At test station C, seven skinfolds (triceps, subscapular, biceps, supraspinale, abdominal, front thigh, medial calf), two girths (arm flexed, calf relaxed), and two bone breadths (biepicondylar humerus, biepicondylar femur), were measured.

All measurements were undertaken by trained anthropometrists using a standardized protocol in accordance with the International Society for the Advancement of Kinanthropometry (ISAK) guidelines (ISAK, 2001). After a duplicate reading, third measures were taken if measurements exceeded 0.5mm in skinfolds and 0.5cm for other variables. A recorder assisted each anthropometrist to improve accuracy and reduce test time. Following the ISAK protocol, the mean (of duplicate scores) and median (for triple scores) were entered into an Excel spreadsheet.

Data Analysis

There were a total of eight events for each gender. Numbers in each event varied from one to 38, thus athletes were assigned to one of five groups: throw, jump, sprint (100m, 200m and 400m), distance (middle distance, long distance, race walking events) and hurdle (100m, 110m and 400m). Five heptathletes and decathletes were excluded because there were three or less cases for each gender. All data were checked for accuracy at least twice during data entry before subsequent data analysis.

The data were transferred to SPSS version 13.0 (SPSS Inc.) and Excel 2003 (Microsoft Inc.) for statistical analysis. Somatotype was derived using the Heath-Carter somatotype scale (Carter & Heath, 1990). The dependant variables were the three somatotype components and their mean somatopoint. The mean somatopoint was calculated as the resultant vector of the three components and somatotype attitudinal distance (SAD) was used to describe spread about the mean somatotype (Carter et al., 1983). SAD was calculated with the following equation:

SAD =
√ _ (ENDOmean-ENDOindv)2 + (MESOmean-MESOindv) 2 + (ECTOmean-ECTOindv) 2 _

Before comparing means, the data was examined for normality within groups for each variable. Groups were considered non-normal if the Shapiro-Wilk statistic was significant ($P<0.05$) or the ratio for either the skewness or kurtosis statistics to their standard error was greater or less than 2. Initial results indicated four groups were non-normal over a range of variables. Examination of histograms, box plots and Q-Q graphs suggested this was possibly due to outliers. Any cases that were further than two standard deviations from the mean score in any variable for their group were removed (8 cases). This meant only the male ($P=0.001$, ratio=2.16) and female ($P=0.008$, ratio=1.38) throw groups demonstrated skewness in the ectomorphy component. Because the ratios of skewness to standard error were close to 2 (Vincent, 1999), this was deemed sufficient to continue. From the original 108 cases, 95 were retained for statistical analysis of mean somatopoint and its components.

According to the instructions derived from Carter & Heath (1990), the mean somatopoint was first analyzed. In the event of a significant difference between groups the three individual components of the somatotype were then analyzed. As this approach entailed 8 comparisons (4 dependant variables x 2 genders) the Bonferroni correction was used to set the significance level at $P<0.00625$.

The data were split for analysis by gender and the differences between the means of the five groups were analysed with ANOVA or Brown-Forsythe's test when the Levene's test indicated heterogeneity of variances in the dependant variable (i.e. when $P<0.05$). Omega squared (_2) provided effect sizes for the ANOVAs. In the case of a significant ANOVA, Tukey's HSD post hoc test was used to identify which pairs of groups differed significantly. If heterogeneity of variances was present Games-Howell was used to determine post hoc which pairs of groups contributed to the significant Brown-Forsythe test. Cohen's d provided effect sizes for pair-wise comparisons. Somatotype components were not analysed with MANOVA because the low sample sizes of several groups reduced their ratio of cases to dependant variables below 3:1. The Levene's test on the mean somatopoint was used as an indication of the difference between groups in the somatopoint1 spread.

Results & Discussion

Basic Characteristics

Table 1. Physical variables of subjects (mean and standard deviation).

Variables	Male (n=58)	Female (n=37)	Total (n=95)
Age (years)	18.2±1.7	17.0±1.6	17.7±1.7
Weight (kg)	64.5±14.3	55.1±12.4	60.9±14.3
Height (cm)	169.8±5.9	160.0±5.6	166.0±7.5
Sum of seven skinfolds (mm)	61.1±43.3	94.2±42.1	74.0±45.6
Flexed arm girth (cm)	30.3±4.2	26.4±4.9	28.8±4.8
Calf girth (cm)	37.2±4	34.9±4.5	36.3±4.3
Humerus breadth (mm)	6.8±0.5	6.1±0.4	6.5±0.6
Femur breadth (mm)	9.5±0.6	9.1±0.8	9.3±0.7
Somatotype	2.7-5.2-2.8	3.9-4.4-2.7	3.1-4.9-2.8
SAD	1.3±1.0	1.6±0.8	1.4±0.9

Male Somatotypes by Groups

On average, the male athletes were classified as balanced[2] mesomorphs, with mean somatotype of 2.7-5.2-2.8. It is placed at the upper central area in the somatochart (Figure 1). This somatotype rating represents a physique, which has more musculoskeletal robustness than either linearity or roundness.

It is notable that the male mean somatotype is shifted to the left of the somatochart due to low ectomorphy rating of the throw group. The median of the mean somatotype is 2.1-4.9-2.9, which is located slightly right of the mean somatotype.

The somatoplots of male athletes by group (Figure 1) show the mean somatotype for jump, power, distance and hurdle athletes clustered in the meso-ectomorphy sector of the somatochart. The male jump, sprint and hurdle athletes were ectomorphic mesomorph, with average somatotypes of 2.0-4.5-3.4, 2.1-5.1-2.9, and 1.9-4.7-3.4, respectively. On the other hand, distance athletes were mesomorph ectomorph (2.2-4.2-3.7). For the male throw group, the somatotype rating of 5.9-7.5-0.7 was in the upper region of the meso-ectomorphy sector of the somatochart.

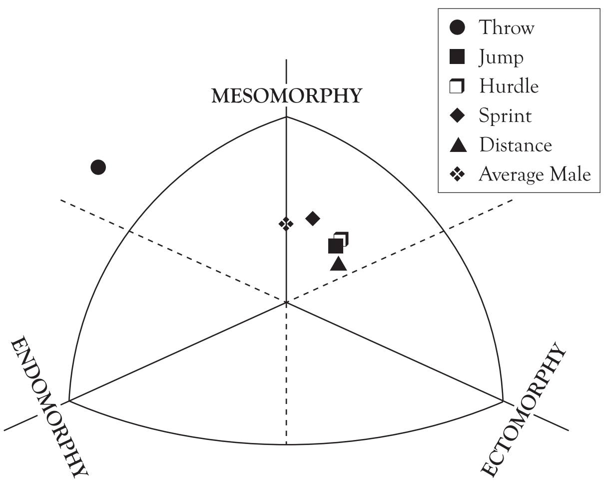

Figure 1: Somatoplots of male track and field athletes by group.

Table 2. Somatotype of male track and field athletes by group.

Groups	n	Component	Mean	SD	Low	High
Throw	9	Endomorphy	5.9	2.3	4.1	7.6
		Mesomorphy	7.5	1.9	6.1	9.0
		Ectomorphy	0.7	1.0	-0.1	1.5
		SAD	2.8	1.2	1.9	3.6
Jump	6	Endomorphy	2.0	0.2	1.7	2.2
		Mesomorphy	4.5	1.4	3.0	6.0
		Ectomorphy	3.4	1.3	2.1	4.8
		SAD	1.6	1.0	0.6	2.6
Sprint	27	Endomorphy	2.1	0.3	1.9	2.2
		Mesomorphy	5.1	0.9	4.8	5.5
		Ectomorphy	2.9	0.7	2.6	3.1
		SAD	1.1	0.6	0.8	1.3
Distance	11	Endomorphy	2.2	0.2	1.8	2.6
		Mesomorphy	4.2	0.6	3.8	4.6
		Ectomorphy	3.7	0.6	3.2	4.1
		SAD	0.9	0.5	0.5	1.2
Hurdle	5	Endomorphy	1.9	0.3	1.5	2.3
		Mesomorphy	4.7	0.6	3.9	5.3
		Ectomorphy	3.4	0.4	2.9	3.8
		SAD	0.7	0.3	0.3	1.1
TOTAL	58	Endomorphy	2.7	1.7	2.2	3.1
		Mesomorphy	5.2	1.5	4.8	5.6
		Ectomorphy	2.8	1.2	2.5	3.1
		SAD	1.3	1.0	1.1	1.6

Levene's Test indicated heterogeneity of variance in the male data for all variables, except for ectomorphy. Subsequent Brown-Forsythe testing showed significant differences among male groups between their mean somatopoints (P=0.001, _2=0.33). When the Brown-Forsythe's test by component was applied, significant differences were found in the endomorphy (P<0.001, _2=0.66) and mesomorphy (P<0.001, _2=0.46). On the other hand, the ANOVA showed a significant difference for ectomorphy (P<0.001, _2=0.57) variables. Table 3 shows the pairs that contributed to a significance difference for each variable.

Despite being significantly less ectomorphic than the four other groups, the male throw athletes were also more endomorphic than the jump and hurdle athletes and more mesomorphic than the distance athletes. In addition, sprint athletes were significantly more mesomorphic than the distance athletes.

Female Somatotypes by Groups (Table 4, Figure 2)

The mean somatotype rating for all female athletes was 3.9-4.4-2.7, which is slightly left of the central category of the somatochart. The mean somatotype for female throw athletes was 6.6-7.2-0.6, an extreme endomorph-mesomorph. On the other hand, female jump and distance athletes were balanced ectomorph, falling along the ectomorphic

Table 3. Significant post hoc tests between pairs of male groups for each variable.

Component	Groups	Mean Difference first - second (±99.375% CL)	Effect Size (Cohen's d)
Endomorphy†	Throw - Jump	3.9 (± 3.9)	3.0
	Throw - Hurdles	4.0 (± 3.9)	3.0
Mesomorphy†	Throw - Distance	3.4 (± 3.1)	2.7
	Sprint - Distance	1.0 (± 0.9)	2.1
Ectomorphy*	Throw - Jump	-2.7 (± 1.5)	-2.4
	Throw - Sprint	-2.1 (±1.1)	-2.5
	Throw - Distance	-3.0 (± 1.3)	-3.7
	Throw - Hurdles	-2.6 (± 1.6)	-4.0

** Comparisons made with Tukey's HSD post hoc test are significant at P<0.00625.*

axis in the somatochart with average somatotypes of 3.3-3.0-3.6 and 2.7-2.9-4.4 respectively. Sprint and hurdle athletes averaged somatotypes of 3.0-3.7-3.2 and 3.2-4.2-2.9, respectively. These two groups clustered around the centre of the somatochart's mesomorphic sector.

Like the male group, the mean somatotype of the female athletes was biased to the left of the somatochart due to low ectomorphy rating of the throw group. The median of the mean somatotype is 3.0-4.0-2.9, which is placed lower right of the mean somatotype, at the central region of the somatochart.

Table 4. Somatotype of female track and field athletes by group.

Groups	N	Component	Mean	SD	Low	High
Throw	9	Endomorphy	6.6	1.3	5.6	7.6
		Mesomorphy	7.2	2.2	5.5	8.9
		Ectomorphy	0.6	0.6	0.1	1.1
		SAD	2.3	1.0	1.5	3.1
Jump	7	Endomorphy	3.3	0.8	2.6	4.1
		Mesomorphy	3.0	1.2	1.9	4.1
		Ectomorphy	3.6	0.6	3.1	4.2
		SAD	1.4	0.4	1.0	1.8
Sprint	13	Endomorphy	3.0	0.6	2.6	3.4
		Mesomorphy	3.7	1.3	3.0	4.5
		Ectomorphy	3.2	0.9	2.6	3.8
		SAD	1.5	0.7	1.0	1.9
Distance	4	Endomorphy	2.7	0.9	1.3	4.0
		Mesomorphy	2.9	0.8	1.6	4.1
		Ectomorphy	4.4	0.7	3.3	5.5
		SAD	1.2	0.2	0.9	1.5
Hurdle	4	Endomorphy	3.2	0.8	1.9	4.4
		Mesomorphy	4.2	0.9	2.7	5.7
		Ectomorphy	2.9	0.7	1.8	3.9
		SAD	1.4	0.1	1.2	1.6
TOTAL	37	Endomorphy	3.9	1.8	3.3	4.5
		Mesomorphy	4.4	2.2	3.7	5.1
		Ectomorphy	2.7	1.5	2.2	3.2
		SAD	1.6	0.8	1.3	1.9

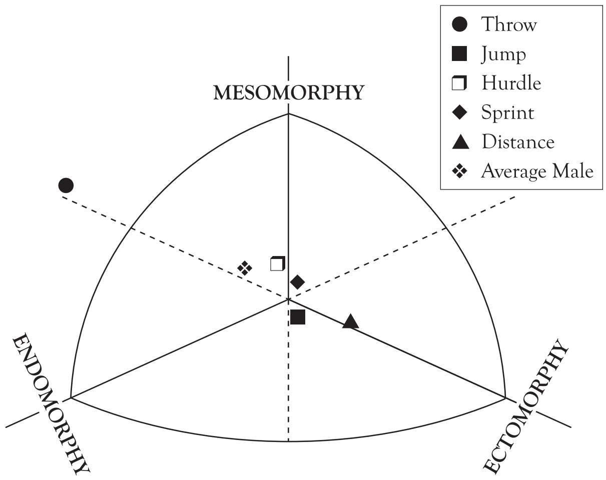

Figure 2. Somatoplots of female track and field athletes by group.

Levene's Test of the female data indicated that the mean somatopoint and mesomorphy variables had heterogeneous variances. The subsequent Brown-Forsythe tests found significant differences among female groups in their mean somatopoint (P<0.001, _2=0.44) and a significant difference among means for mesomorphy (P<0.001, _2=0.74). One-way ANOVA by component revealed significant differences in group means for endomorphy (P<0.001, _2=0.54) and ectomorphy (P<0.001, _2=0.73). Table 5 shows the pairs identified by Tukey's HSD (endomorphy and ectomorphy pairs) and Games-Howell (mesomorphy pairs) that contributed to a significant difference for each variable, that is, the mean difference between the pairs was significant at P<0.00625.

Female throw athletes showed the greatest difference in endomorphy and ectomorphic components compared to other groups. They were also more mesomorphic than the jump and distance athletes.

Discussion

In the present study, male and female athletes showed significant differences among the five groups in their mean somatotypes and components. Lower SAD coefficient in male athletes indicated a more homogeneous grouping,

Table 5. Significant post hoc tests between pairs of female groups for each variable.

Component	Groups	Mean Difference First group - second group (±99.375% CL)	Effect Size (Cohen's d)
Endomorphy*	Throws - Jump	3.3 (± 1.7)	0.8
	Throws - Sprint	3.6 (± 1.4)	1.0
	Throws - Distance	4.0 (± 2.0)	1.0
	Throws - Hurdle	3.5 (± 2.0)	0.9
Mesomorphy†	Throws - Jump	4.2 (± 3.7)	2.5
	Throws - Distance	4.4 (± 3.7)	2.9
Ectomorphy*	Throws - Jump	-3.0 (± 1.4)	-5.3
	Throws - Sprint	-2.6 (± 1.2)	-3.5
	Throws - Distance	-3.8 (± 1.7)	-6.1
	Throws - Hurdle	-2.3 (± 1.7)	-3.9

** Comparisons made with Tukey's HSD post hoc test are significant at P<0.00625.*
† Comparisons made with Games-Howell post hoc test are significant at P<0.00625.

probably due to a greater specialization in events. This is also reflected in the male somatochart (Figure 1) where the somatoplots had lower dispersion and clustered around the upper meso-ectomorphic sector of the somatochart.

Orientation of Somatotypes

When the orientation of the mean somatotypes for the five groups are compared between the male and female athletes (Figures 1 and 2), the average somatoplots for both genders run along a line from the extreme endo-mesomorphy for throw athletes, terminating approximately at the meso-ectomorphy region for distance athletes. The mean somatotypes of the female athletes are almost parallel to those of males, but lower on the somatochart. This indicates that the male athletes are more mesomorphic, but less endomorphic than the female athletes with little difference on ectomorphy. These data conform to the pattern of Olympic track and field athletes (Carter, 1984b). This pattern of a greater muscular development and less adipose tissue development in the male compared to the female athletes has been observed in many athletic and non-athletic populations.

Somatotypes by Groups

Male and female throw groups showed significant differences in somatotype compared to the other four groups. As shown in the somatochart (Figures 1 and 2), the throw groups appeared to be consistently separated from the other groups. Throw athletes had highest mesomorphy and endomorphy ratings, but the lowest ectomorphy rating (<0.7). This may have resulted from the heavier body weight, larger skinfolds, wider bone breadths and arm circumference relative to stature, compared to the other groups. These anthropometric characteristics are necessary for success in events that require force to overcome reactive resistance of an object, such as the shot and discus in the throw events.

Distance athletes were found to be the most ectomorphic and least mesomorphic among the five groups in both genders. They showed less musculoskeletal development and smaller muscle circumferences. This observation was also found in the studies on elite track and field athletes (Carter, 1984b). This somatotype illustrated the physical characteristics of weight-bearing distance events, where small frontal cross sectional area are required for superior endurance performance.

Sprint and hurdle athletes were found to be mesomorph-dominant. However, for both genders, somatopoints were plotted at the meso-ectomorphic region in the somatochart. According to Battinelli (2000), strength and speed dependent athletes tended to be ranked high in mesomorphy (scoring at least 5.5), but low in ectomorphy. In the present study, however, we found that both the sprint and hurdle athletes were classified within moderate ranges (rating between 2.9-5.1) of mesomorphy and ectomorphy.

Somatotypes in Talent Identification

Somatotype, although a general physical characteristic, can be important to athletes when other variables that make up a high level performance are equal (Bloomfield et al., 1994). Being phenotypical, it is desirable that somatotype is taken into account in the selection of athletes for junior training program to ensure chance of success in a particular sport.

A limitation of the use of somatotype in talent identification is that the performance of an athlete is not measured relative to body size, shape or composition. Thus, the somatotypes of athletes within given sports activities, although similar to some extent, were dissimilar relative to size and proportions within given events (Battinelli, 2000). For instance, high jump requires that the athletes are lean so there is less mass to propel upwards, however the height attained is not measured relative to their body heights. Therefore, in addition to being ectomorphic, it is desirable to be tall in stature as indicated by the jumping group's percentile height ranking. The male and female jump athletes were taller than the average athlete at the SUKMA games, being respectively ranked in the 65th and 82nd percentile for height. Therefore, results from the somatotype must be considered along with how performance in the event (or sport) is judged and whether some absolute body measurement provides an advantage.

In some instances it seems logical to group different events into one single group e.g. shot put, discus, hammer and javelin. Yet each event requires very different skill sets and body type, with javelin requiring a run up and whip like throw action, hammer and discus rely on control of rotation momentum and shot-put a push-like throw. In the present study, hurdlers were initially included in the sprinting group, however, when the two groups were separated it was found that the male hurdlers were less endo- and mesomorphic, and more ectomorphic than the pure sprinters.

Comparison to Olympic Athletes

The data for this study were compared to Olympic elite groups from Carter (1984b) (Figures 3 and 4). Carter (1984b) studied 452 male athletes from three Olympic Games and 116 female athletes from two Olympic Games from 1960 to 1976. The age range was 15-42 for men and 18-38 for women (Carter, 1984a).

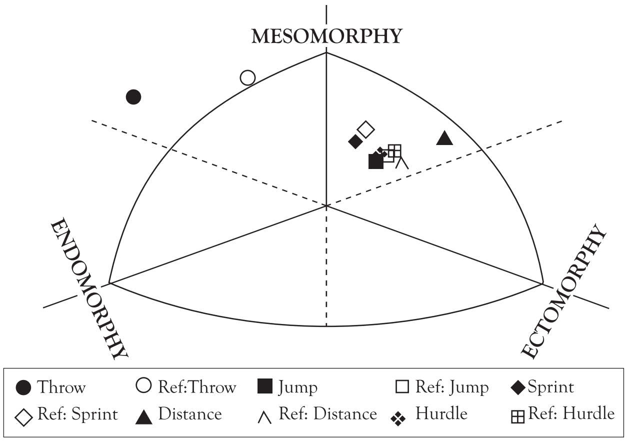

Figure 3. Comparison between male study group and elite group (Carter, 1984b).

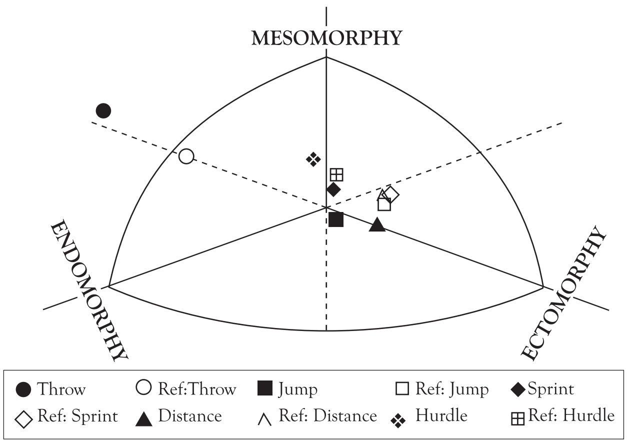

Figure 4. Comparison between female study group and elite group (Carter, 1984b).

Despite the fact they were younger, the present study male athletes possessed similar somatotypes compared to their Olympic counterparts (Figure 3), apart from the throw athletes who were more endomorphic (more than 2.5 unit difference) than the Olympic group from Carter (1984b).

For female athletes, the present groups were similar to the Olympic athletes in somatotype except that the jump and sprint groups were more endomorphic (mean difference 1.0, and 1.1 respectively) than their Olympic counterparts. The throw group was also more mesomorphic (mean difference 1.9) and less ectomorphic (mean difference -1.9) than the Olympic athletes.

Comparison to Student Athletes

The data for this study were compared with young Brazilian student athletes (n=218) aged 16 to 18 years (Guimaraes & De Rose, 1980). The male athletes of the present study were generally more endomorphic and mesomorphic, but less ectomorphic. The male throw athletes in the present study were more mesomorphic, but less ectomorphic than the student groups. Also, it was found that the male hurdle athletes were more ectomorphic than the student hurdle athletes. On the other hand, the somatotypes of female groups for both studies were similar except that jump athletes in the present group were more mesomorphic but less ectomorphic (Table 6).

Table 6. Comparison of somatotype between study group and student group (Guimaraes & De Rose, 1980).

Component	Event	Mean Difference[a-b] (Effect size)	
		Male	Female
Endomorphy	Throw	2.80 (1.6)	-
	Jump	0.23 (0.6)	0.35 (0.4)
	Sprint	0.30 (0.7)	0.20 (0.3)
	Distance	0.60 (2.4)	0.10 (0.1)
	Hurdle	0.30 (1.0)	-
Mesomorphy	Throw	2.48 (2.7)	-
	Jump	0.70 (0.8)	0.75 (1.0)
	Sprint	0.70 (0.7)	0.40 (0.5)
	Distance	0.20 (0.2)	-0.30 (0.4)
	Hurdle	0.50 (0.6)	-
Ectomorphy	Throw	-0.95 (1.0)	-
	Jump	-0.85 (0.7)	-1.10 (1.8)
	Sprint	-0.40 (0.5)	0.30 (0.4)
	Distance	-0.30 (0.4)	0.70 (1.0)
	Hurdle	0.50 (1.1)	-

[a] *Data from present study*
[b] *Data from Guimaraes & De Rose (1980)*

Conclusions

These results provide the first description of the somatotype of young Malaysian track and field athletes. When compared to adult Olympic and young Brazilian student athletes, the Malaysian athletes had similar anthropometric characteristics. However, both the male and female throw athletes were more endomorphic than the Olympic and student groups. This suggests that appropriate training regimens and nutritional plans need to be implemented to modify the body morphology to one that would most likely enhance athletic performance.

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