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Somatotyping in Adolescents: Stratified by Sex and Physical Activity

Research Article

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Abstract

Background: Somatotyping is a method for describing the human physique in terms of a number of traits that relate to body shape and composition. Somatotypes of athletes in selected sports are quite different from one another. It is also used to describe changes in physique during growth, ageing and training as well as in relation to physical performance. Somatotyping gives more information than some typical measures of body composition such as body fat percentage and body mass index that is useful in determining what type of sports will be suitable for an individual.
Objective: School is a place where any type of intervention can bring about a substantial change in the physique of an individual and it is also a place where children are involved in various types of sports. The objective of the study is to somatotype school children and to find any sex difference if present.
Methodology: Somatotyping consists of numerical ratings for adiposity (endomorphy), musculo-skeletal development (mesomorphy), and slenderness (ectomorphy). The anthropometric somatotype can be calculated from a set of 10 measurements: height, weight, four skinfolds (triceps, subscapular, supraspinale and medial calf), two biepicondylar breadths (humerus and femur) and two girths (upper arm flexed and tensed, and calf). The anthropometric measurements and somatotyping was done, based on Heath-Carter anthropometric somatotyping.
Results: We have somatotyped children of a residential rural school in Pondicherry. We observed that somatotype of girls and boys were significantly different. Endomorph physique was more in girls, while mesomorph and ectomorph physique was dominant in boys.
Conclusion: Somatotyping children in school will help us to identify specific physique deficiency and to help them in choosing the sports of their choice.

Keywords: Somatotyping; Children; Ectomorphy; Endomorphy; Mesomorphy.

Introduction

Somatotyping describes the human physique in terms of subcutaneous adipose tissue (endomorphy), musculoskeletal development (mesomorphy) and relative slenderness or linearity (ectomorpy). The classification of somatotype is made using anthropometric measurements and body composition or using photoscopic method. The earlier method is considered more accurate than the photoscopic method [1]. Evidences have demonstrated that somatotype varies with age, sex, nutritional status [2-4] and physical activity [5]. Anthropometric and physiological characteristic of sports person vary according to each discipline [6]. Somatotyping that has long been used for identification of sports talents [7] as individuals with morphological characters favorable for specific sport is known to give best performances [8]. Previous studies have shown that somatotype components are related to cardiovascular disease and disease risk factors. Identification of somatotype at an earlier age will help us provide appropriate lifestyle modification or physical activity according to their needs. Nutrition, activity adaptations and genetic background forms the basis of population difference in somatotypes [9, 10]. Even BMI stratification is different for Asian population. Somatotype is considered to be more inheritable than BMI and hence it is required to establish

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somatotype for each population. The objective of our study is to assess the somatotyping of adolescent individuals stratified by sex and physical activity.

Materials And Methods

Study design

The study was conducted in the Department of Physiology, JIPMER, Pondicherry, India from 28th March 2012 to 30th June 2013. The somatotype data presented here is collected as a part of a larger randomized control trial (Registration No. CTRI/2013/08/003897). We commenced the study after getting approval from the JIPMER Scientific Advisory Committee and the Institute Ethics committee for Human studies.

Participants

Participants were male and female students from the age group of 12 to 17 years. All the participants were from a rural residential school (Jawahar Navodaya Vidyalaya), in Pondicherry, India. The study protocol was explained and 315 volunteers were included in the study after obtaining their written assent and the written informed consent from their respective parents or local guardians. We then subdivided the participants based on their sex and physical activity status (athlete males = 31, athlete female = 25, non-athlete males = 144, non-athlete females = 115). Any study volunteer who has been undergoing regular sport-specific physical training for at least 25 hours a week (minimum 2 hours daily training for six days a week) and representing the school at state and/or national level sports meets was considered as athlete.

Parameters

Anthropometric measurements: Anthropometric measurements were made by personnel, certified by International Society for the Advancement of Kinanthropometry (ISAK) following the instructions given in the Heath-Carter Anthropometric Somatotype Instruction Manual. Height was measured using a wall mounted stadiometer (V M Electronics Hardware Ltd) accurate to the nearest 0.1 cm. Weight was measured using a digital weighing scale (Charder Electronic Co. Ltd Taichung, Taiwan 2013) accurate to the nearest 0.1 kg. Skinfold thickness was measured from four sites (triceps, subscapular, supraspinale and medial calf) using a clinical Plicometer Innovare (CESCROF Sports Equipment Limited, Porto Alegre – Rio Grande do Sul, Brazil) Flexed and tensed arm girth and calf girth were measured using non stretchable anthropometric tape (CESCROF Sports Equipment Limited, Porto Alegre – Rio Grande do Sul, Brazil). Humerus and femur breadths (epicondylar) were measured using small bone calipers (CESCROF Sports Equipment Limited, Porto Alegre –Rio Grande do Sul, Brazil) with an accuracy of 0.1 mm.

Skinfold values, breadth values and girth values were taken in triplicate, accurate to the nearest 0.1 mm, and the average of the three recordings was then used for further analysis.

Somatotype calculation

Somatotype of the school children were calculated using Heath carter formulae (Table 1).

Qualitative comparison of somatotype between two groups can be done by using somatotype categories. Somatotypes were classified into seven larger groups as instructed by Heath and Carter in their instruction manual (Table 2).

Quantitative comparison of two groups is by somatotype attitudinal distance (SAD), which is the difference in component units between two somatotypes. The SAD was calculated using the following formula:

Table 1: Formulae for the calculation of the anthropometric Heath-Carter somatotype by computer.

Endomorphy	$- 0.7182 + 0.1451 X – 0.00068 X^2 + 0.0000014X^3$	
Mesomorphy	0.858 HB + 0.601 FB + 0.188AG + 0.161CG – 0.131 SH + 4.5	
Ectomorphy	0.732 HWR – 28.58	If HWR > 40.74
	0.463 HWR -17.63	If 38.25 < HWR = 40.74
	0.1	If HWR ≤ 38.25

X= (sum of triceps, subscapular and supraspinale skinfolds multiplied by (170.18/height in cm); HB = Humerus breath (cm) ; FB = femur Breadth (cm); AG = corrected arm girth (cm) (arm girth –(triceps skinfold (mm)/10); CG = corrected calf girth (cm) (calf girth - (medial calf skinfold (mm)/10)); SH = standing height (cm); HWR = height in cm over cuberoot of weight.

Table 2: Somatotype categoreies.

Central	No component differs by more than one unit from the other two
Endomorph	Endomorphy is dominant, mesomorphy and ectomorphy are more than one-half unit lower
Endomorph-mesomorph	Endomorphy and mesomorphy are equal (or do not differ by more than one- half unit and ectomorphy is smaller
Mesomorph	Mesomorphy is dominant, endomorphy and ectomorphy are more than one-half unit lower
Mesomorph-ectomorph	Ectomorphy and mesomorphy are equal (or do not differ by more than one- half unit and endomorphy is smaller
Ectomorph	Ectomorphy is dominant, mesomorphy and endomorphy are more than one-half unit lower
Ectomorph-endomorph	Ectomorphy and endomorphy are equal (or do not differ by more than one- half unit and mesomorphy is smaller

Table 3: Anthropometric data.

Anthropometric parameters	Non-athlete female (115) Mean	SD	Non-athelte male (144) Mean	SD	Athlete female (25) Mean	SD	Athlete male (31) Mean	SD	ANOVA	Non-athlete Female vs male	Athlete Female vs male	Female non-athlete vs athlete	Male non-athlete vs athlete
Height (m)	1.51	0.08	1.56	0.13	1.54	0.08	1.57	0.10	.001	.000	.865	.806	1.000
Weight (kg)	44.12	7.36	46.66	9.86	46.52	5.97	47.03	8.20	.087	.107	1.000	.749	1.000
BMI	19.34	2.22	18.92	1.76	19.72	2.00	19.03	1.78	.153	.418	.723	.943	1.000
Triceps (mm)	14.43	4.56	10.18	4.22	14.52	3.87	10.00	4.73	.000	.000	.001	1.000	1.000
Subscapular (mm)	13.38	4.57	10.38	4.15	12.72	4.61	10.39	5.26	.000	.000	.275	.984	1.000
Supraspinale (mm)	9.93	4.24	7.53	4.04	9.52	2.99	7.87	5.07	.000	.000	.596	.998	.999
Medial calf (mm)	16.10	5.62	9.15	4.05	14.40	4.46	9.03	3.76	.000	0.000	.000	.475	1.000
Humerus breadth (cm)	5.70	0.46	6.15	0.67	5.92	0.40	6.26	0.58	.000	.000	.163	.384	.927
Femur breadth (cm)	7.50	0.71	8.80	0.71	7.78	0.65	8.88	0.62	.000	0.000	.000	.346	.994
Arm circumference (cm) Flexed and tensed	21.81	2.57	21.89	4.06	21.70	1.88	23.36	5.70	.181	1.000	.438	1.000	.228
Calf circumference (cm)	28.65	3.64	28.45	4.42	28.8	2.66	29.6	4.79	.561	.999	.977	1.000	.635

Analysis done by one way ANOVA followed by Hochberg's GT2 post hoc analysis.

Table 4 : Global somatotype analysis - Comparison of somatotype categories.

Somatotype category	Non-athlete female (115)	Non-athlete male (144)	Athlete female (25)	Athlete male (31)
CENTRAL	9	8	2	1
ENDOMORPH	50	17	12	4
ENDOMORPH MESOMORPH	8	9	3	0
MESOMORPH	4	36	1	13
MESOMORPH ECTOMORPH	0	1	0	0
ECTOMORPH	28	68	4	13
ECTOMORPH ENDOMORPH	16	5	3	0
Total	115	144	25	31
Chisquare overall	< .001			
Chisquare Female vs male	< .001 (non-athletes)		< .001 (athletes)	
Chisquare Non-athletes vs athlets	.918 (Females)		.391 (males)	

Table 5: Separate component analysis.

	Non-athlete female (115) Mean	SD	Non-athelte male (144) Mean	SD	Athlete female (25) Mean	SD	Athlete male (31) Mean	SD	ANOVA	Non-athlete Female vs male	Athlete Female vs male	Female non-athlete vs athlete	Male non-athlete vs athlete
endomorph	3.66	1.24	2.72	1.21	3.77	1.01	2.67	1.30	.000	.000	.005	.999	1.000
mesomorph	2.34	1.05	2.97	1.27	2.39	1.23	3.50	1.72	.000	.000	.006	1.000	.178
Ectomorph	2.79	1.14	3.33	1.13	2.78	1.09	3.31	1.10	.001	.001	.400	1.000	1.000

$$SAD = \sqrt{[(ENDO_A - ENDO_B)^2 + (MESO_A - MESO_B)^2 + (ECTO_A - ECTO_B)^2]}$$

Any SAD value >0.5 is practically considered to be of significant difference.

The raw values of each component of somatotype are classified as mild (< 2.5), moderate (<5), high (<7) and extremely high (>7). Finally, we have classified the athletes based on their type of athletic activity (basket ball, football, kabaddi, runner, sprint) and their somatotype category is listed in (Table 7).

Statistical analysis

Anthropometric Data analysis: Data are expressed in Mean ± Standard Deviation (SD). For comparison of groups based on both sex and physical activity stratification, one way ANOVA followed by Hochberg's GT2 post hoc analysis was used.

Somatotype analysis:

Global component analysis:

- Somatotype category: We have expressed the somatotype categories as frequencies along with their percentages for each group and the data were analyzed. Somatotype categorical data was analyzed using Chi Square test.

- Somatochart-visual analysis: plotting of mean somatotype of various groups in somatochart.

- Somatotype altitudinal distance (SAD): Absolute values are compared.

Table 6: frequency and percentage distribution of mild, moderate, and high level of scoring in each component of somatotype.

	Non-athlete female (115)		Non-athelte male (144)		Athlete female (25)		Athlete male (31)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Endomorph								
Mild	22.00	19.10	69.00	47.90	4.00	16.00	16.00	51.60
Moderate	70.00	60.90	67.00	46.50	18.00	72.00	13.00	41.90
High	23.00	20.00	8.00	5.60	3.00	12.00	2.00	6.50
Total	115.00	100.00	144.00	100.00	25.00	100.00	31.00	100.00
Ectomorph								
Mild	43.00	37.40	38.00	26.40	8.00	32.00	7.00	22.60
Moderate	71.00	61.70	92.00	63.90	17.00	68.00	22.00	71.00
High	1.00	0.90	14.00	9.70	0.00	0.00	2.00	6.50
Total	115.00	100.00	144.00	100.00	25.00	100.00	31.00	100.00
Mesomorph								
Mild	67.00	58.30	47.00	32.60	12.00	48.00	10.00	32.30
Moderate	47.00	40.90	86.00	59.70	13.00	52.00	15.00	48.40
High	1.00	0.90	11.00	7.60	0.00	0.00	6.00	19.40
Total	115.00	100.00	144.00	100.00	25.00	100.00	31.00	100.00

Table 7: Comparison of somatotype categories between various athletic activities

Somatotype category	Basketball		Football		Kabaddi		Runner		Sprint	
	Female (7)	Male (8)	Female (4)	Male (11)	Female (8)	Male (5)	Female (4)	Male (5)	Female (2)	Male (2)
CENTRAL					1	1			1	1
ENDOMORPH	3				4	2	2	2	1	
ENDOMORPH MESOMORPH			2		1					
MESOMORPH				11	1	1				1
Mesomorph ectomorph										
ECTOMORPH	3	8	2			1	1	3		
ECTOMORPH ENDOMORPH	1				1		1			

Separate component analysis:

Data are expressed in Mean ± SD. For comparison of groups based on both sex and physical activity stratification, one way ANOVA followed by Hochberg's GT2 post hoc analysis was used.

Results

Table 1 shows the formulae that were used for the computer based calculation of the Anthropometric Heath - Carter Somatotypes. The description of each somatotyping categories are given in Table 2.

Table 3 shows anthropometric data for all the groups (non-athlete male, non-athlete female, athlete male athlete female). Analysis between the groups by one-way ANOVA has shown significant difference in height, all the skinfold thickness (Triceps, subscapular, supraspinale and medial calf) and breadths (Humerus and Femur) but not in weight and circumferences.

On post hoc analysis we observed that the statistically significant difference in one way ANOVA test is mainly because of gender difference in non-athletes. There was no significant difference between non-athletes and athletes in both the gender, and the gender difference in athletes is minimum.

Global component analysis

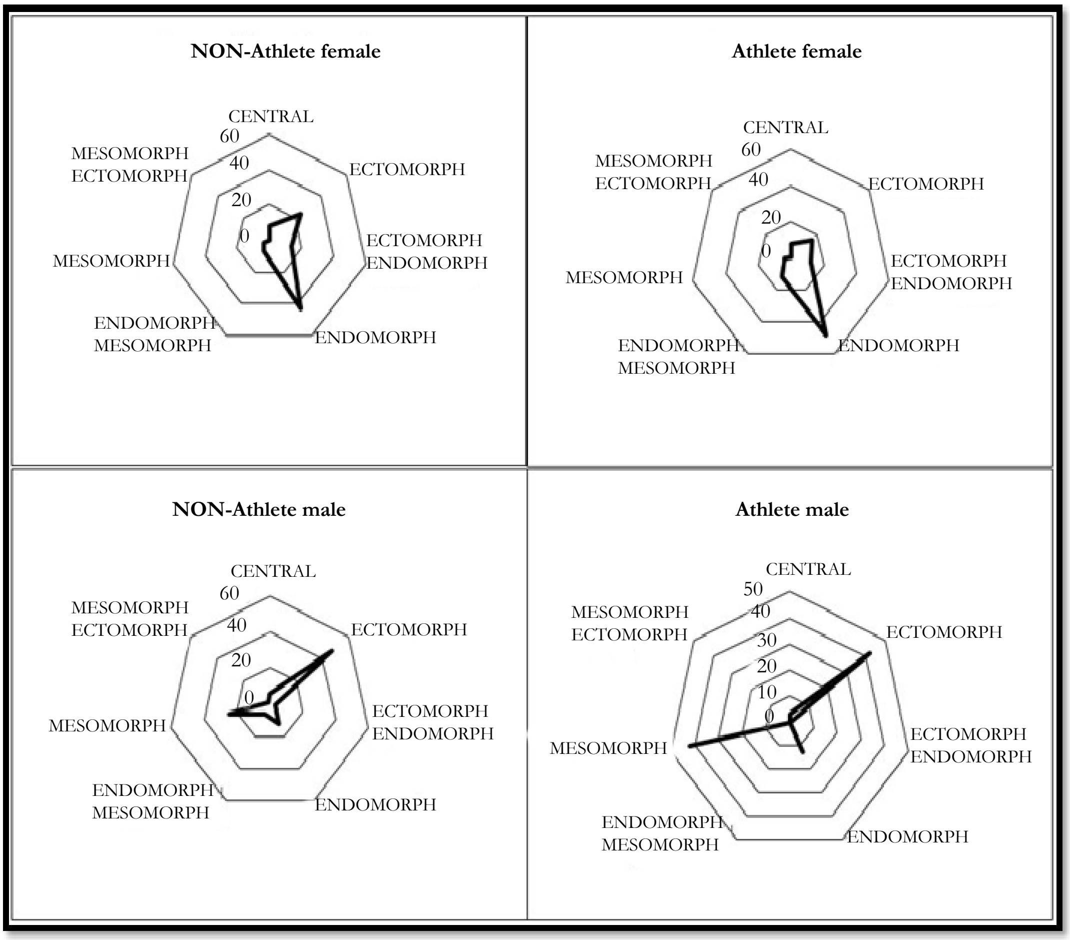
Table 4 shows comparison of somatotype categories between the groups. There was statistically significant difference between females and males whether they are athletes or non-athletes. There was no significant difference between athletes and non-athletes whether they are females or males. We have presented the same data in percentage in figure 1 for better understanding of distribution of somatotype categories between various groups, showing comparison of somatotype categories between the groups.

Somatotype attitudinal distance between various groups is as follows: Non-athlete female vs athlete female (0.121), non-athlete male vs athlete male (0.533), non-athlete female vs non-athlete male (1.253), athlete female vs non-athlete male (1.319). The result shows that somatotype attitudinal distance was significant between non-athlete female vs non-athlete male and athlete female vs athlete male. Borderline significance was observed in non-athlete male vs athlete male. The diagrammatic representation of the distance between the groups is given in figure 2.

Separate component analysis

Table 5 shows separate component analysis. One way ANOVA analysis shows that groups were significantly different in all the somatotype components. Post hoc analysis showed that none of the components were significantly different between athletes and

Figure 1 . Percentage distribution of somatotype category.



non-athletes of both genders.

Endomorphic component is significantly more in both athlete and non-athlete females than their male counter parts. Mesomorphic component is significantly more in athlete and non-athlete in males than their female counter parts. Ectomorphic component was in non-athlete male than non-athlete female but the same observation was not seen in athlete males and females.

Table 6 shows frequency and percentage distribution of mild, moderate, and high level of scoring in each component of somatotype. There were no extremely high values in any of the component in any of the group. Individuals in high category are also very less in all of the component in all the groups.

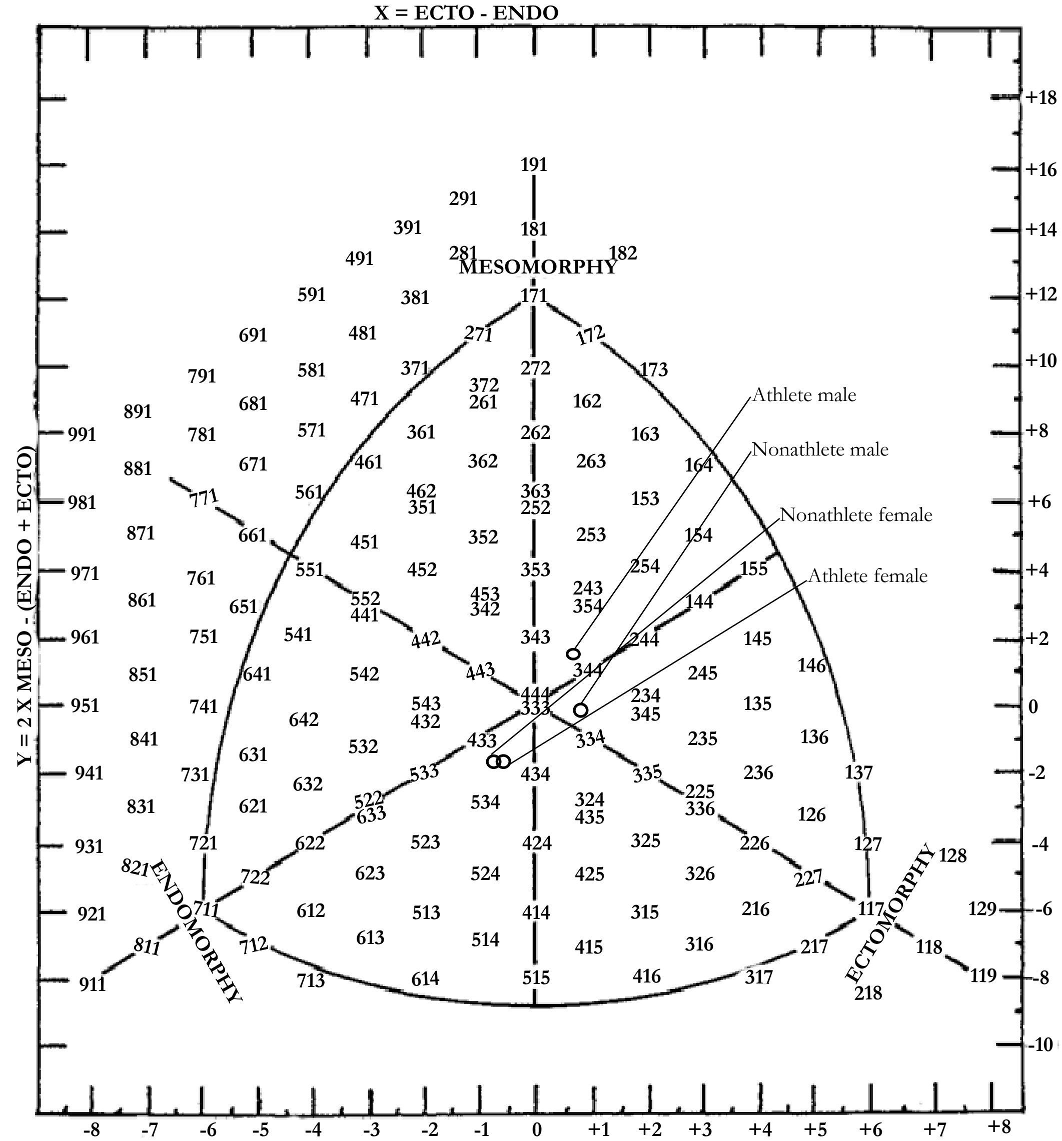
Table 7 shows the somatotype category of the individuals pursuing various sports. We observed that there was no specific somatotype distribution with respect to type of sports.

Discussion

Somatotype is the quantified expression of the morphological conformation of an individual. It consists of three components viz, endomorphy, mesomorphy and ectomorphy, that describe the relative degree of adiposity, musculoskeletal development and slenderness of an individual respectively. Somatotype category is a more qualitative description of an individual in terms of dominant component or components (Table 2). Routine body composition measures such as BMI/body fat% cannot give a wholesome picture of the body physique. BMI cannot differentiate between fat mass or muscle mass. Body fat percentage cannot differentiate persons with different muscle mass and height. Hence somatotyping can be considered superior to these conventional body composition parameters [11]. Recent studies have demonstrated positive correlation of certain type of somatotypes with specific disease risk. For example, ectomorphic somatotype is associated with the risk of developing hypertension. Further, it has been proven that each discipline of sports has specific somatotype pattern [12, 13]. Since Somatotype has been found to be genetically determined to an greater extent than BMI [5], it would be challenging to change the somatotype of an individual to suit a particular sport or to reduce the disease risk. By identifying the somatotype at an earlier age we could help the children to choose appropriate sports that can bring out their athletic performance better. Further, introducing appropriate behavioral changes according to their somatotype can reduce the disease risk to some extent. We have given the sex and physical activity stratified somatotype data (Table 5) which can be considered as a normative data for the rural school children. In children during thier phase of physical growth spurt, there is a tendency to show higher endomorphy and ectomorphy and a decrease in mesomorphy [14, 15]. We observed that dominant somatotype pattern in females is endomorphy while the dominant somatotype pattern in males are mesomorphy and ectomorphy with equal distribution (Figure 1).

In the present study, we observed that anthropometric measure-

Figure 2. Somatochart.



ments were significantly different between non-athletic males and non-athletic females. While all the skin fold thickness were higher in females, breadths (femur and humerus) were higher in males. Our results are consistent with Toselli et al., who has reported higher endomorphy and less mesomorphy in females as compared to males. However they have reported similar ectomorphy between both sexes [16]. This may be because the study was done in the age group of 6-10 years. In our study ectomorphy was higher in males. This goes hand in hand with observation by Inuka Gakhar et al who have reported that ectomorphic pattern increases af-ter 13 years onwards in males. Our study population comprises of students of aged between 12-17 years and this may be reason why ectomorphic patter was higher in males. Inuka Gakhar et al also reported increasing endomorphism pattern in females from young adolescent to late adolescent [3] which further supports our observation. Gender difference was not so obvious between athlete males and females. This may be because athletic level training would have reduced the fat mass (endomorphy) and increased the muscle mass (mesomorphy) in females as reported by Skunta Saha et al [17].

Engaging in sports activity reduces the difference in somatotype components and body composition among the individuals involved in same type of physical activity and hence, somatotype and body composition can serve as markers for assessing benefits of respective sports activities [12, 13]. However, we observed no difference in anthropometric parameters between athletes and non-athletes of both genders. As a result of this, there was no difference in somatotype components also. Our study contradicts the findings of Skunta Saha et al who have reported less body fat % and increased muscle mass in athletes compared to non-athletes [17] and Ji Woong Noh et al. who have reported difference in weight, body mass index and somatotype components between judo athletes and non-athletes [18]. However, we observed that mesomorphy was non-significantly higher in athlete male than non-athlete male. The lack of difference may be due to smaller sample size. We attribute the lack of difference between athletes and nonathletes due to the following reasons. Firstly, in our study we have combined athletes of various discipline in single group. As the training for each sports differs their somatotype will also change according. We have not compared each discipline separately with non-athletes because of the lack of sample size. Secondly, both athletes and non-athletes belong to the same socio-economic status and ethnicity. Since somatotype shows higher inheritable pattern this reason could be considered for the lack of difference between non-athletes and athletes [15, 19]. Third, the non-athletes in our study were not sedentary and were practicing minimum one hour of physical activity as a part of school curriculum. From our previous study we have found that practice of systematic unstructured physical activity per hour on daily basis for a year can help the adolescent to uphold their body composition similar to the athletes of same age and gender [20]. Fourth, the pattern of food did not differ much between them since they all were dining in the same mess. Nutrition is considered to be one of the major factor that can influence somatotype [4]. Fifth, since our study is in adolescents the duration of athletic training varies from 2 to 4 years only. This duration may not be enough to bring about significant change compared to their non-athletic peers. These points have to be considered before comparing athletes and nonathletes in adolescent age group in future studies.

The somatotype component of a sports individual describes the significant features of their sports [21-23]. In the current study, we observed that there was non- specific somatotype distribution for various sports activities. A study conducted on Luthuanian male athletes have reported distribution of endomorphic pattern in basketball players, ectomorphic pattern in foot ball players [24]. One Indian study has documented endomorphic mesomorph somatotype distribution in kabbadi players [25]. Whereas, in our study we did not find the distribution of fit athletes into appropriate sports activities. Creating awareness of somatotyping and its importance among school children and sports coaches will help them in selecting suitable candidates for sports and for giving appropriate training for bringing their athletic potential.

Conclusion

To conclude, Somatotyping components and pattern distribution varies with sex and physical activity. Predominantly endomorphic pattern was seen among female and ectomorphic pattern was seen among male subjects. Though there was not variations in somatotype pattern between athletes and non-athletes there was significant variation in somatotype components and somatotype attitudinal distance. Subjects involved in various athletic events were not engaged in appropriate sports according to their physique. General awareness of somatotyping can help the person to choose appropriate sports which suits their physique.

Limitations of the study

The athletic sample size was small. The distribution of somatotyping pattern in different athletic event could not be described/suggested for the population due to inadequate subjects under each athletic event. In view of the somatotyping which is known to change with age and the period of adolescence assessing somatotyping in adolescent population and by categorizing based on early or late adolescence period could have provided additional informations.

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