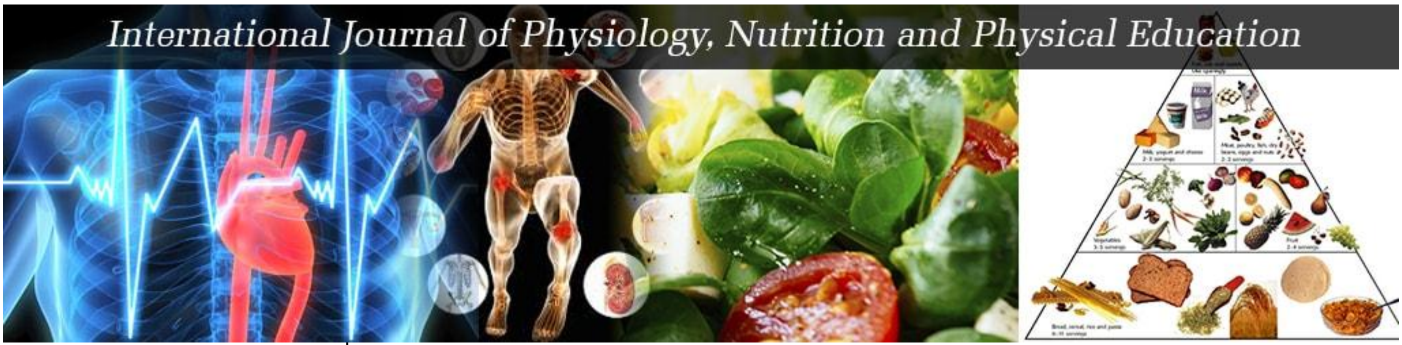

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Determination of somatotyping in 8- to 14- year males in the Districts of Chandauli and Mirzapur Uttar Pradesh, India

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Abstract
Somatotype characteristics of children were studied in the districts of Chandauli and Mirzapur, Uttar Pradesh, India with an age range between 8 yrs. and 14 years. Five hundred and one male children were studied randomly. Mesomorphic Eectomorph body type was obtained for all children except the eight year children when average vales were considered. Significant difference was observed among the different age groups. 14 year-old children were more mesomorphic among the all age groups whereas 12 year and 13 year-old children were more ectomorphic.

Keywords: children, somatotype, ectomorph, mesomorph, Uttar Pradesh

1. Introduction

Somatotype is defined as the quantification of the human body in three components like Endomorphy, Mesomoprhy and Ectomorphy where endomorphy represents fattiness; Mesomorphy represents mscularity and Ectomorphy for linearity. In growth studies, evaluation of the somatotype is particularly important in providing estimates of changes over time associated with children's growth and development (Carter and Heath 1990, Monyeki *et al.*, 2002) [16]. Sheldon (1940) [21], the originator of Somatotype thought that the somatotype is genetically determined and it follows a definite pathway. However, it has now been established beyond doubt that the somatotype ratings do change, especially during adolescence (Barton & Hunt, 1962; Heath & Carter, 1971; Hunt & Barton, 1959; Parizkova & Carter, 1976; Walker, 1978; Zuk, 1958; S. P. Singh and L. S. Sidhu, 1980) [14, 17, 22]. Keeping in view the somatotype changes taking place during growth, an attempt was made to know the pattern of change of somatotype components across an age span of several years in the cross-sectional sample of the male children from Chandauli and Mirzapurdistricts of Uttar Pradesh.

2. Methodology

2.1 Subjects

The present cross-sectional study was conducted on primary and secondary school children of government schools in the districts of Chandauli and Mirzapur, Uttar Pradesh, in the academic year 2014–2015on a total of 501 male children. The multistage random sampling approach was taken into consideration with ages ranging from 8 to 14 years. The distribution of the sample has been mentioned in Table 1. The ages of the children were determined from their dates of birth in their school registers. They participated in this research voluntarily and cheerfully without any compulsion. Consents were taken from the parents as well as from school authorities prior to the measurements. The study was approved by the Research Ethics Committee of Pondicherry University.

Table 1: Distribution of Subjects with Respect to Age Classification.

S. No.	Age (years)	No. of children in Chandauli district	No. of children in Mirzapur district	Total number of children
1	8	35	35	70
2	9	31	31	62
3	10	33	32	65
4	11	27	28	55
5	12	38	37	75
6	13	39	38	77
7	14	48	49	97
Total		251	250	501

2.2 Protocol for Kinanthropometric Measurements

Athropometric measurements were followed standard protocol of The International Society for Advancement of Kinanthropometry (ISAK) and method was followed accordingly (ISAK manual 2012). All measurements were taken only for the right-hand side of the body parts. Height was measured with an anthropometric rod to the nearest 1mm. Body mass was measured in kilograms to the nearest 0.1 kg using an electronic weighing scale. All skinfold measurements (triceps, subscapular, supraspinal and medial calf) were taken with the Harpenden skinfold caliper. Biepicondylar humerus width and biepicondylar femur width were measured to the nearest 1 mm using a small sliding caliper. Upper arm and calf girth were measured with an anthropometric tape (Lufkin). All measurements were taken using cross-hand technique with 1 mm graduation. The corrections were done as proposed by (Hebbelinck *et al.*, 1973) [8] with Technical Error of Measurements (TEM).

2.3 Determination of Somatotype

For the assessment of somatotyping, the Heath – Carter somatotype technique was applied. There are 10 body measurements required such as height, weight, fours kinfolds, two width and two girth measurements redundant. (Heath & Carter 1967) method was followed for somatotyping rating as follows:

1. *Endomorphy* = –0.7182 + 0.1451(X) – 0.00068(X2) + 0.0000014(X3), where X = (sum of triceps,subscapular and supraspinal skinfolds) multiplied by170.18 (height in cm). This is called height-correctedendomorphy.
2. *Mesomorphy* = (0.858 x humerus breadth) + (0.601 xfemur breadth) + (0.188 x corrected arm girth) +(0.161 x corrected calf girth) – (0.131 x height) + 4.5.(Corrected arm girth = Arm girth - triceps skinfold/10;Corrected calf girth= (maximalcalf girth - calf skinfold)/10.)
3. *Ectomorphy***.** Three different equations are used tocalculate ectomorphy according to the height–weight ratio (HWR).
   i) If HWR is greater than or equal to 40.75, then *Ectomorphy* = 0.732 x HWR – 28.58.
   ii) If HWR is less than 40.75 but greater than 38.25,then *Ectomorphy* = 0.463 x HWR –17.63.
   iii) If HWR is equal to or less than 38.25, then *Ectomorphy* = 0.1.

Formula for Calculating Somatotype Attitudinal Distance

Calculations of somatotype attitudinal means (SAM), based on somatotype attitudinal distance (SAD) were performed using the special procedures for somatotype analyses (Carter, Ross, Duquet *et al.* 1983, Carter and Heath 1990). Somatoplots are two-dimensional projections of the three-component somatotype; hence it is likely that the true distance between somatotypes is distorted. Therefore, the distance between somatotypes was calculated using the three dimensional somatotype attitudinal distance, which is the true distance in component units between any two somatotypes (Duquet and Hebbelinck 1977) [8].

The distance between somatopoints in three dimensions is calculated in terms of component units:

SAD (a,b) =

$$\sqrt{[(\text{endomorphy}_a - \text{endomorphy}_b)^2 + (\text{mesomorphy}_a - \text{mesomorphy}_b)^2 (\text{ectomorphy}_a - \text{ectomorphy}_b)^2]}$$

Where a and b are two individuals, two different times for one individual, or two means.

Formula for Calculating Somatotype Attitudinal Mean

The somatotype attitudinal mean (SAM) is the average of the SADs of each somatotype:

$$\text{SAM} = \sum \text{SAD} / N$$

2.4 Statistical Analysis

Cressie *et al.* (1986) [7] claimed that using SAD, which is the distance between any two somatopoints in three dimensions in the ANOVA procedure, prematurely collapses the three-component somatotype vectors into a scalar SAD value, thereby reducing the degree of freedom for the F ratio. They suggested increasing the degrees of freedom to include those for the three components as separate variables, thus increasing the likelihood of Type I errors when compared with the method of Carter *et al.* (1983). Their basic premise was that the three-somatotype components should be considered together in one-way MANOVA. Mean, standard deviation, maximum and minimum values were used to determine the kinanthropometric characteristics of the children of different age groups. One-way MANOVA was applied to analyse the significant differences between different somatotype groups, and for post hoc test, Bonferroni's adjusted α level is used at $P < 0.002$.

3. Result

Table 2: Descriptive Statistics of Stature in Different Age Groups.

Age group	Minimum	Maximum	Mean	SD
8	111.10	134.00	123.18	6.01
9	115.40	137.70	129.33	5.10
10	121.30	143.80	131.31	5.39
11	122.00	167.50	137.58	8.34
12	127.90	151.80	138.26	5.17
13	133.00	163.20	145.53	6.87
14	133.60	168.20	152.57	8.85

Table 3: Descriptive Statistics of Weight in Different Age Groups.

Age group	Minimum	Maximum	Mean	SD
8	16.60	25.50	20.98	2.34
9	18.20	29.80	23.47	2.69
10	18.50	32.10	24.38	3.31
11	20.30	40.10	27.62	3.49
12	21.70	39.40	28.74	5.50
13	22.30	45.80	32.28	4.95
14	25.20	54.80	38.37	7.12

Table 4: Descriptive Statistics of Somatotyping Group-wise: Somatotype attitudinal mean.

Age group	Samples	Minimum	Maximum	Mean (SAM)	SD
8	70	0.12	2.34	0.85	0.48
9	62	0.27	3.36	0.99	0.60
10	65	0.06	3.30	1.08	0.70
11	55	0.17	2.92	0.93	0.51
12	75	0.20	3.43	1.12	0.70
13	77	0.15	4.01	1.23	0.74
14	97	0.19	3.55	1.35	0.72
Total	501	0.10	3.83	1.18	0.70

Table 4, shows that, for 8-year-olds the maximum value of SAM is 2.34 and the minimum is 0.12, with a mean and SD of 0.85 ± 0.48; for 9-year-olds, the maximum is 3.36 and the minimum is 0.27, with a mean and SD of 0.99 ± 0.60; for 10-year-olds, the maximum is 3.30 and the minimum is 0.06, with a mean and SD of 1.08 ± 0.70; for 11-year-olds, the maximum is 2.92 and the minimum is 0.17, with a mean and SD of 0.93 ± 0.51; for 12-year-olds, the maximum is 3.43 and the minimum is 0.20, with a mean and SD of 1.12 ± 0.70; for 13-year-olds, the maximum is 4.01 and the minimum is 0.15, with a mean and SD of 1.23 ± 0.74; and for 14-year-olds, the maximum is 3.55 and the minimum is 0.19, with a mean and SD of 1.35 ± 0.72.

Table 5: Descriptive characteristics of Somatotyping with respect to age.

Age group	Sample size	Endomorphy (mean and SD)	Mesomorphy (mean and SD)	Ectomorphy (mean and SD)	Categories
8	70	1.51 0.29	3.11 0.73	3.52 0.86	Mesomorph-Ectomorph
9	62	1.33 0.33	3.33 0.53	4.55 0.94	Mesomorphic Ectomorph
10	65	1.41 0.36	3.32 0.74	4.66 0.91	Mesomorphic Ectomorph
11	55	1.33 0.30	3.48 0.72	4.43 0.72	Mesomorphic Ectomorph
12	75	1.31 0.40	3.19 0.71	4.98 1.0	Mesomorphic Ectomorph
13	77	1.25 0.42	3.38 0.80	4.99 0.93	Mesomorphic Ectomorph
14	97	1.38 0.55	3.65 0.82	4.71 1.0	Mesomorphic Ectomorph

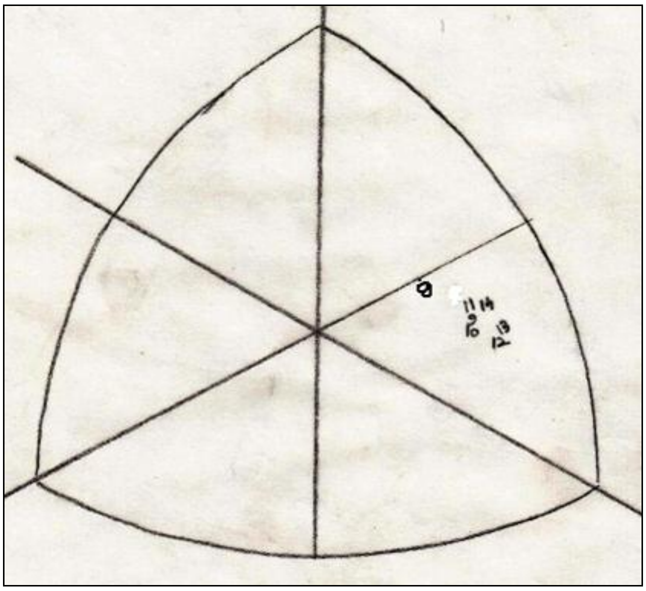

Fig 1: Mean somatotype for different age groups (8 to 14 years).

Table 6: Box's test

Box's M	129.8
F	3.54
df1	36
df2	390,624.21
Sig.	0.000

Box's test was used to test the null hypothesis that the observed covariance matrices of the dependent variables are equal across all groups.

From Table VI, it is clear that Box's M (3.54) is significant, P(0.000) < α(0.001). This indicates that there are significant differences between the covariance matrices. Therefore, the above assumption is violated and Wilks's lambda is not an appropriate test to use; rather we decided to use Pillai's trace test, which is very robust and not highly linked to assumptions about the normality of the distribution of the data (http://www.iasri.res.in/ebook/eb_smar/e-book_pdf%20files/manual%20ii/6-manova.pdf; Kotz and Johnson, 1983).

Table 7: Multivariate Tests.

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial η2
Somatotype components	Pillai's trace	0.179	5.214	18.000	1482.000	0.000	0.097
	Wilks's lambda	0.829	5.316	18.000	1392.071	0.000	0.108
	Hotelling's trace	0.198	5.403	18.000	1472.000	0.000	0.114
	Roy's largest root	0.142	11.664	6.000	494.000	0.000	0.194

The following is the MANOVA using Pillai's trace test. From Table 4.13, Pillai's trace =
0.179, F (18, 1482) = 21,782.5, P < 0.001, multivariate η^2 = 0.09 (α = 0.05). This significant F indicates that there are significant differences among the groups (8 to 14 years) on a linear combination of the three dependent variables such as endomorphy, mesomorphy and ectomorphy.
The multivariate η^2 = 0.09 indicates that approximately 9% of multivariate variance of the dependent variables is associated with the group factor.

Table 8: Levene's Statistics.

Variables	F	df1	df2	Sig.
Endomorphy	4.7	6	494	0.092
Mesomorphy	3.4	6	494	0.083
Ectomorphy	1.8	6	494	0.140

Levene's statistics indicate the equality of error variance tests. The assumption of multivariate analysis and analysis of variance show that the variances of each variable are equal across the groups. Table 4.18 shows that the assumptions are met for all three dependent variables (endomorphy, P > 0.05; mesomorphy, P > 0.05; and ectomorphy, P > 0.05).

Table 9: Between-Subject Effects Test.

Dependent variables	**Type III sum** of squares	**df**	**Mean** square	**F**	**Sig.**	**Partial** η^2
Endomorphy	2.174	6	0.362	2.175	0.044	0.036
Mesomorphy	15.789	6	2.632	4.128	0.000	0.078
Ectomorphy	37.585	6	6.264	6.356	0.000	0.132

For improving the statistical power of the test, the researcher used Bonferroni's procedure at 0.017 (0.05/number of dependent variables). Table 9 shows that two dependent variables are significant at P < 0.001, but endomorphy is significant at P < 0.05, but it is insignificant at P > 0.017. Follow-up tests using univariate ANOVA indicate that two independent variables, namely mesomorphy and ectomorphy, are significantly different among the groups with different degrees of freedom, F(6, 494) = 4.13, P < 0.001, $\eta2$ = 0.8 and F(6, 494) = 6.4, P < 0.001, $\eta2$ = 0.13, respectively.

Bonferroni's Post Hoc Test for Multiple Comparisons of Two Dependent Variables
(Mesomorphy and Ectomorphy) among Groups

Bonferroni's test is commonly used to control Type I error across the pairwise comparison among groups. In this approach, the α level is divided by the number of comparisons among the groups. In this situation, α = 0.017/7 = 0.002. This test is performed to identify the components responsible for these differences in physical structure.

Table 10: Comparison of Mesomorphic Components.

Dependent variables	**(I) group (years)**	**(J) groups (years)**	**Mean of 14 years**	**Mean**	**Mean difference (I–J)**	**SE**	**Sig. (99.8% CI)**
Mesomorphic	14	8	4.0402	3.7539	0.2863	0.12521	0.475
	14	9	4.0402	3.6213	0.4189	0.12982	0.028
	14	10	4.0402	3.5905	0.4497	0.12798	0.010
	14	11	4.0402	3.7811	0.25910	0.13476	1.000
	14	12	4.0402	3.4917	0.5485*	0.12276	0.000
	14	13	4.0402	3.7484	0.2918	0.12186	0.358

*The mean difference is significant at 0.002 level.

Table 10: indicates that a significant difference is obtained when comparing the 14-year to the 12-year age group. It means that the 14-year-old group is more mesomorphic than the other groups at P < 0.001. And, the remaining groups show no significant difference among themselves with respect to the mesomorphic component.

Table 11: Comparison of Ectomorphic Components.

Dependent variables	**(I) group(years)**	**(J) groups(years)**	**Mean of 8 years**	**Mean**	**Mean difference (I–J)**	**SE**	**Sig. (99.8% CI)**
Ectomorphic	8	9	3.7539	4.5447	–0.388	0.173	0.533
	8	10	3.7539	4.6565	–0.500	0.171	0.076
	8	11	3.7539	4.4264	–0.270	0.179	1.000
	8	12	3.7539	4.9797	–0.823*	0.165	0.000
	8	13	3.7539	4.9849	–0.829*	0.164	0.000
	8	14	3.7539	4.7072	–0.551	0.156	0.009

*The mean difference is showing significant at 0.002 level.

Table 11 indicates that a significant difference is obtained between the 8-year and the 12-year age groups and between the 8-year and 13-year age groups with respect to the ectomorphic component at P < 0.001. It indicates that the 12-year and 13-year age groups are more ectomorphic. The rest of the groups seem to have no significant difference among them with respect to the ectomorphic component.

4. Discussion

Somatotype attitudinal distance (SAD), in three dimensions, is the distance between any two somatopoints (the plot of a somatotype in three dimensions). The SAD is the average of the somatopoints from the mean of a sample (Duquet and Hebbelinck, 1977) [8]. SAM assesses the deviation between the somatotypes and the subjects' mean somatotype. The bigger the value of the measurement of SAM obtained, the less homogenous is the group and vice versa. As per Heath and Carter formulations (1990), fluctuations can be said to be high (SAM ≥ 1.0), moderate (SAM 0.80–0.99) and low (SAM ≤ 0.79). The large SAM (mean = 1.35; SD = 0.72) is recorded for the age group of 14 years and the minimum value (mean = 0.85; SD = 0.48) for 8 years. This might be indicated in the time periods of the biological variations with regard to growth and maturation of the respective samples as given in the studies of Malina and Bouchard (1991) [15].

The results of one-way MANOVA, wherein somatotype components are combined and evaluated (Cressie *et al.*, 1986) [7], clearly show that body topology seems to have statistical difference among the group means of somatotyping components. Bonferroni's post hoc test shows that the 14-year-old children are more mesomorphic than the other age groups, while the 12- and 13-year-old children are more ectomorphic than the rest of the groups. The means for somatotype components at different ages in male children of Chandauli and Mirzapur are given in Table 4.11: in the 8-year-old children, the somatotyping is (1.51-3.11-3.52), but at the age of 14 years the somatotyping is (1.38-3.65-4.71), the intensity of components changes with respect to age. Therefore, the somatotype of the general population changes in component dominance (Singh and Sidhu, 1980; Amigóa *et al.*, 2009).

During the age of 8 to 14 years, there is an overall decrease of 0.13 and 0.54 units in the endomorphic and mesomorphic components, respectively; while a 1.19 unit increment is recorded in the ectomorphic component. The male children of Chandauli and Mirzapur are maximum endomorphic at an early age. From 14 years onwards, they have increasing endomorphic ratings. The maximum variability is recorded in the 14-year-old group of the children. There is a decreasing trend in the mesomorphic ratings up to 12 years, and a slight increment is recorded from 13 years onwards. The ectomorphic rating increases with age from 8 to 13 years. At 13 years, the highest ectomorphic rating is recorded. Afterwards, there is a tendency to decrease in this component. The overall results show that the two components of somatotyping (i.e. endomorphy and mesomorphy) have a tendency to decrease with an increase in the age of the children and there is an overall increment in the ectomorphy component with respect to the age groups. These results are in agreement with the findings of Singh and Sidhu (1980), Monyeki *et al.* (2002) [16], Ventrella *et al.* (2008) [24] and Amigóa *et al.* (2009). At the age of 13 to 14 years, there are fluctuations recorded in the components of somatotyping. The height spurt occurs at a mean age of 13.5 years in boys (Abbassi, 1998) [1].

Therefore, this may be the stage (puberty stage) showing valuable change in human growth and in this stage all three components of somatotyping are altered. At the age of 13 to 14 years, the body has a higher tendency to longitudinal development than to transverse development (Singh and Sidhu, 1980). From Table4.11, boys of the Chandauli and Mirzapur districts are having linear development that is evident from the ectomorphy rating. The somatotype components are derived from the Heath–Carter formula; endomorphy depends upon three skinfolds and corrected height measurements and mesomorphy depends upon two width measurements i.e. calf circumference and arm girth and also height. The third component (ectomorphy) depends upon height-weight ratio. In this stage, maybe due to longitudinal development, the rating of ectomorphy is greater. In this study, the children are found under BMI range (below 17). Several authors have found a strong relationship between body mass index and body fat percentage. According to Adams *et al.* (2007), the relationship between BMI and body fat percentage in the severely obese has been obtained. Spearman's correlations between all BMI and percent fat values were R = 0.80 and R = 0.83 for men and women, respectively. According to Ranasinghe *et al.* (2013) [18] (a cross-sectional study), a significant positive correlation was observed between BMI and BF%: in males r = 0.75 (P < 0.01) and in females r= 0.82 (P < 0.01) of all ages. Effect of age and gender in the BMI–BF% relationship was significant (P < 0.001). These two studies show that BMI is positively related to percentage of body fat; r = 0.8 and r = 0.75 show that 64% and 56% relationships are obtained by their findings. The endomorphy topology is like globular or fattier. Here, an indirect relationship is obtained between endomorphy and BF%.

In this present research, the maximum and minimum values of endomorphy are 1.5 and 1.31, respectively. This shows that the value of endomorphy is less than those of ectomorphy and mesomorphy, and the BMI obtained is below 17, which is under the threshold value. Perhaps indirectly due to the lowering of BMI, the rating of endomorphy is less.

Malina and Bouchard (1991) [15], Carter and Heath (1990) and Amigóa *et al.* (2009) stated that the physique of the human body is influenced by environmental factors including regular exercise, balanced diet (nutrition), health habits (personal hygiene), illnesses or diseases and when biological maturation occurred. Therefore, the knowledge of biological diseases and the state of treatment facilities as well as the prevalent social customs could be helpful in assessing and analysing the causes of high ectomorphy in this populace. The prevalent social customs and practices regarding children in the rural areas of the Chandauli and Mirzapur may be a major cause of relative stability and high ectomorphy in the somatotype components. During interaction with the children, it was found that most of them had to leave for school foregoing breakfast and thus went through the whole morning without food till the midday meal.

More research needs to be done to assess the role played by the environment and genetics to find out why some children had more stable somatotypes than others, i.e. if the somatotype is inherited among the population.

The rural populations of the districts of Chandauli and Mirzapur have a very low standard of living economically and belong to the most backward districts and both are receiving funds from the Backward Regions Grant Fund Programme (BRGF) (Ministry of Panchayati Raj, 8 September 2009). The socio-economic status is revealed in the school-going children who are subjects of the present study. Though the schools provide free midday meals to students who attend classes, the children are often malnourished due to lack of proper nutrition at home. Often, they do not have a regular breakfast and the midday meal at school is their first food of the day.

5. Conclusion
Overall, based on the analysis, and within the limitations of the study, the results obtained lead to the following conclusions:

1. The mean value of somatotype for all age groups were mesomorphic-ectomorph throughout the complete age range, while the mean somatotype for 8year male was mesomorph-ectomorph
2. The somatotype of male children was stable across the whole age range except for the 8-year-old male children group. It showed considerable stability for all age groups.

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