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What Happens to Children When They Grow up?

How Does the Human Body Change After the Age of 18

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A B S T R A C T

The present study answers the question on how the human body changes in two successive decades after its final height had been reached. One hundred and three individuals (56 males and 47 females) who were followed up longitudinally by a team of scientists from birth to 18 years of age were investigated anthropometrically by 18 body measurements again when they reached the age of between 35 and 39 years. The Carter-Heath somatotype was ascertained as a part of the study. The results of the investigation at the age of 35 to 39 years were compared with the Czech Standard and with those from 18 years of age. The means of all measurements in both sexes increased with age (with the exception of stature in females). Relative measurements and indices, which were calculated only in the groups of 35–39 year-olds were all on the average greater in males than in females with the exception of relative head circumferences and pelvis width, in the pelvis width in per cent of biacromial width, in the sum of skinfolds, and in the gross percent of body fat. Males as well as females increased from the age of 18 to 35–39 as a rule in weight, muscle, bone and fat mass, which were manifested by a shift towards endomorphic and mesomorphic components of their somatotypes away from the ectomorphic one.

Key words: *children, growth, adult age, changes in anthropometrical measurements, somatotypes*

Introduction

All people were or are children. It is an interesting idea that world wide known personalities such as Aristotle, Alexander the Great, Comenius, Darwin, Queen Elizabeth, the poet Seifert, Churchill, Pope John Paul II, Napoleon, etc. were once children and that from some of the children of to day will grow up leading personalities of tomorrow. From a newborn baby there develops a toddler, from

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a toddling child a preschool and schoolchild, adolescent and sooner or later he or she enters adulthood. We mean physical adulthood which comes before the mental one. The age when this happens is usually 18 to 20 years. Officially it means that one has the right to vote, to possess a driving license and in males to enter the military service.

From the biological point of view adulthood is connected with the cease of growth which is in most Czech girls at 16 and in most Czech boys at 18 years of age. The genetic endowment as well as the entire health care and life style during the growing period are mirrored in the final stature at adulthood. The present study shows a) the extent of anthropometric growth in 18 body dimensions between 18 and 35–39 years, and b) how it is reflected in terms of somatotype change in the course of that life period. Differences in absolute and relative measurements between male and female bodies are also given in the paper.

Materials and Methods

The results are based on anthropometrical investigation of 103 individuals (56 females and 47 males) in the age from 35 to 39 years from one Prague quarter (Žižkov) who were followed up anthropometrically, clinically and psychologically from birth to adulthood and in whom complete records on nutrition, health state and social and family background are known[1–8]. Eighteen measurements were taken at each visit according to the recommendation of the International Children's Center in Paris[9], including head length and breadth, waist circumference, and a skin fold over the biceps[10,11] which we have added. The collected data have been processed by variation statistics (arithmetical means, SDs, t-tests), indices and the total fat were calculated. Somatotypes after Carter and Heath[12] were also calculated from the measurements. Measurements from the age of 35–39 years were compared with those taken at the age of 18 and with data on the contemporary adult Czech Population[13].

Results

Comparison with the contemporary Czech adult population

In comparison with the contemporary adult Czech population[13], females from our sample at the age between 35–39 are significantly taller which corresponds well with their city origin, with their higher educational status and also with the secular trend. They differ also significantly in femur width, waist circumference (smaller in our group) and in suprailiac skinfold (larger in our group).

Our men are also taller than the Czech standard, but insignificantly. A significant difference was found in head circumference and in all four skin folds. Both males and females from our sample exceed the Czech standard in subcutaneous fat probably because of a sedentary way of life and more caloric food in the city dwellers (Table 1).

On the whole the coincidence of both the compared groups may be viewed as satisfactory. The mean height in our males is 178 cm, and in females 166.9 cm, weight in males 81.7 kg and in females 65.0 kg.

Changes in the body measurements from 18 to 35–39 years

Information on growth and on stature after reaching the adult height are based mainly on cross-sectional studies. Following up of the same individuals after 18 years of age is rare. Table 2 shows the result of comparison of the mean body measurements of the members of our sample who were examined both at the age of 18 and between 35–39 years of age by the same investigator.

TABLE 1
COMPARISON OF PRESENT SAMPLE (GROUP 1) WITH CZECH STANDARD (GROUP 2[13])

Traits	Females			Males		
	Group 1 N = 52	Group 2 N = 93	sign. p	Group 1 N = 42	Group2 N = 95	sign. p
Weight (kg)	64.89	65.00		81.70	80.20	
Height (cm)	166.86	162.50	<0.01	178.00	176.99	
Chest circum (cm)	87.04	89.20		100.20	99.90	
Head circum. (cm)	55.25	54.90		58.40	57.10	<0.01
Upp. arm circ. (cm)	27.52	27.80		31.25	30.60	
Calf circum. (cm)	37.01	36.20		38.96	38.50	
Femur width (cm)	9.32	9.70	<0.01	10.10	10.00	
Humerus width (cm)	6.33	6.30		7.15	7.20	
Biiliocr. width (cm)	28.74	28.40		29.05	29.20	
Biacromial width (cm)	36.09	36.20		40.24	40.30	
Biceps skinfold (mm)	8.77	9.90		7.24	5.00	<0.01
Triceps skinfold (mm)	19.02	19.40		13.41	9.40	<0.01
Subscapular sk. (mm)	17.37	18.00		20.88	14.70	<0.01
Suprailiac sk. (mm)	19.93	13.20	<0.01	27.01	12.20	<0.01
Waist circumf. (cm)	78.00	82.40	<0.01	91.27	90.50	

The means of the 35–39 year group changed significantly from the age of 18 years in the following measurements:

In females it was in weight, chest and waist circumferences, in upper arm and calf girths, in femur width, biiliac and bicristal widths, in relation of the bicristal width to shoulder width (PACR), in subscapular and suprailiac skinfolds, in the sum of four skinfolds, and in the BMI. Other traits remained unchanged (i.e. height) or changed only insignificantly (Table 2).

An image of an overall increase of the body as well as of putting on weight and fat results from the findings. It corresponds to reaching a full bodily »maturation« which is typical for the change of lass to a true female.

All measurements with the exception of sitting height and humerus width increased significantly with age in males from 18 to 35–39 years of age. The male body thus expanded towards an all round bigger figure (evidently due to an increase of muscle mass and skeleton) and to an increase of circumferences due to inner and subcutaneous fat. Stature increased significantly in males too, at an average by 0.46 cm, but with considerably big individual differences.

The differences in stature between the age of 18 and 35–39 years were in 70% of males and females smaller than 1 cm, plus and minus. Differences bigger than 1 cm in the minus sense were found in 13% of females and in 9% of males. These were in the plus sense in 10% of females and in 21% in males.

Differences in the mean traits in both sexes (with the exception in stature in females) were positive and in the majority significant. They manifest the enlargement of given widths, thicknesses, circumferences and weight. Growth attained its maximum at the age of 18 years in females, but that cannot be said of males in whom some are still »adding« height even after the age of 20. Observation of the dieticians that the difference of 1 cm in the waist circumference equals 1 kg in weight

TABLE 2
CHANGES IN SELECTED BODY MEASUREMENTS AND INDICES FROM 18 TO 35-39 YEARS OF AGE

Traits (kg,cm,mm)	Females (N = 56)				Males (N = 47)			
	18	35–39	Diff.	sign. p	18	35–39	Diff.	sign. p
Weight	60.93	66.99	6.06	0.001	68.90	81.16	12.26	<0.001
Height	167.25	167.23	–.02		178.24	178.70	.46	0.016
Sitting height	88.84	88.97	.14		93.63	93.64	.01	
Head circum.	55.11	55.28	.17		57.49	58.33	.84	<0.001
Chest circum.	84.29	88.22	3.93	<0.001	91.21	99.95	8.73	<0.001
Waist circum.	73.86	79.44	5.59	<0.001	78.66	91.17	12.51	<0.001
Upp. arm circ.	25.74	28.04	2.30	.004	27.71	31.14	3.43	<0.001
Calf circum.	36.62	37.38	.77	.014	37.10	38.82	1.73	<0.001
Head length	18.08	18.11	.03		19.03	19.19	.16	<0.001
Head breadth	15.16	15.19	.03		15.96	16.15	.19	<0.001
Femur width	9.17	9.39	.22	<0.001	9.97	10.09	.13	0.016
Humerus width	6.36	6.36	.01		7.13	7.14	.01	
Biiliocr. width	27.05	28.91	1.86	<0.001	27.66	28.98	1.32	<0.001
Biacrom. width	35.86	36.22	.35	0.036	39.30	40.26	.96	<0.001
Biceps skinf.	10.39	9.87	–.52		5.32	7.00	1.68	<0.001
Triceps skinf.	17.79	19.63	1.84		10.36	13.31	2.95	<0.001
Subscap. skinf.	16.45	19.53	3.08	.005	11.38	19.76	8.38	<0.001
Suprailiac. sk.	16.23	21.44	5.20	<0.001	11.63	26.41	14.78	<0.001
BMI	21.76	23.92	2.16	<0.001	21.67	25.39	3.71	<0.001
PACR	75.04	79.96	4.92	<0.001	69.92	72.03	2.11	<0.001
Sum of skinf.	60.87	70.47	9.60	0.006	38.69	66.48	27.79	<0.001

has been confirmed. An increment of 6 kg in the course of 18 years in the weight in females coincided with an increase of waist girth by 6 cm. In males the mean increase in weight was about 12 kg and in waist girth about 12 cm.

Body proportions in 35–39 year olds

Some traits and indices which characterize adult males and females were calculated in the age group 35–39 only. They are given in Table 3. They include e.g. relative dimensions in which the value of one trait is expressed in per cent of another one, or in per cent of stature. As an example may be shown the biiliocristal width in per cent of shoulder width, the leg length calculated as stature minus sitting height, the sum of skin folds and the total body fat. Table 3 shows that females differ significantly from males of the same age in all traits given in the table with the exception of relative head circumference, relative femur width, and in the sum of skin folds. The width of the pelvis expressed in the shoulder width is significant with its low value for a typical male (android) figure, and with its high value for a typical female (gynoid) figure. The traits of males in Table 3 exceed those of females with the exception of head circumference in % of stature, in width of pelvis in % of stature, in width of pelvis in % of shoulder width, in the sum of skin folds and in the gross % of fat in the body.

Change of somatotypes from 18 to 35 years of age

Repeated estimation of somatotype in same individuals in the course of time is quite rare in the world literature. Shel-

TABLE 3
MEAN MEASUREMENTS AND INDICES AT THE AGE OF 35-39 YEARS OF AGE

Measurements	Females (N=57)		Males (N=51)		
	X	SD	X	SD	sign. p
Height – sitting height	78.20	4.79	85.30	5.06	<0.01
Chest circ. in % of height	52.72	5.26	55.90	4.67	<0.01
Head circ. in % of height	33.10	1.28	32.66	1.39	
Upp. arm c. in % of calf c.	74.74	6.62	80.23	5.14	<0.01
Femur width in % of height	5.61	0.40	5.65	0.23	
Humerus width in % of height	3.80	0.19	4.01	0.14	<0.01
Humerus w. in % of femur w.	67.90	3.57	71.05	2.89	<0.01
Biiliocr. w. in % of height	17.28	0.95	16.25	0.78	<0.01
Biiliocr. w.in % of biacr.w.	79.86	5.31	72.14	3.22	<0.01
Biacrom. w in % of height	21.67	1.03	22.55	0.88	<0.01
Sum of skinfolds	67.85	35.27	65.41	28.21	
Per cent of Fat in the body	28.64	7.84	21.64	4.36	<0.01

don[14] established most of his »somatotypes« shown in his »Atlas of Man« in military personnel and students around 20 years old and he did not expect such changes in later life that would need a reassessment. The expected unchanged somatotype throughout life led to criticism of his method jointly with the rigid 7 -point system and the limits given by his triangle which could not accommodate extreme thin and extreme muscular or obese types. Carter and Heath[12] modified Sheldon's method[14] leaving his basic principles and nomenclature. They opened, where necessary, the borderlines of the triangle and used more than 7 points wherever they found it useful. They also developed a method how to calculate somatotypes based on 10 anthropometric measurements (though they recommend to use photographs for eventual correction of the final somatotype).

Results showing changes of somatotypes in our males and females from 18 to 35–39 years of age are given in Table 4 and in Figures 1 and 2. Changes in the components of somatotypes due to age are, with an exception in ectomorphic females, statistically significant.

Changes in females: When we round up individual components to whole numbers, we get in females at the age of 18 years somatotypes 5-4-3, which is mesomorph-endomorph, close to the center. At the age of 35–39 years we get when we round up the figures, 6-5-3 which means a substantial change as a sequence of

TABLE 4
CHANGES OF SOMATOTYPES FROM 18 TO 39 YEARS OF AGE

Somatotype	Females (N = 56)				Males (N = 47)			
	18	35–39	Diff.	sign. p	18	35–39	Diff.	sign. p
ENDO	4.95	5.92	.97	<0.001	3.18	5.49	2.31	<0.001
MESO	4.06	4.93	.87	<0.001	4.62	5.82	1.20	<0.001
EKTO	2.72	2.77	.04		3.31	2.49	–.82	<0.001

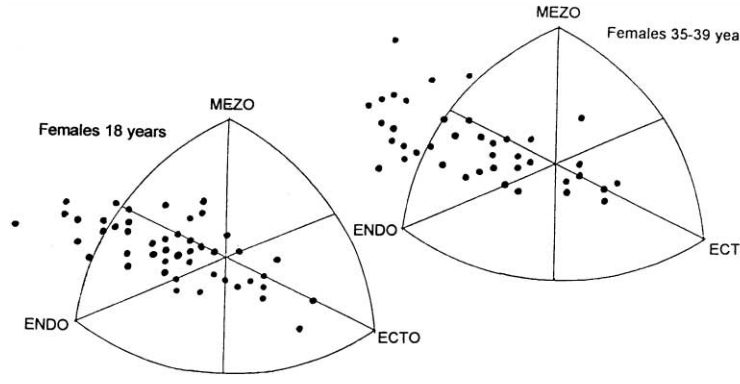

Fig. 1. Changes in somatotypes from 18 to 35–39 years of age in females.

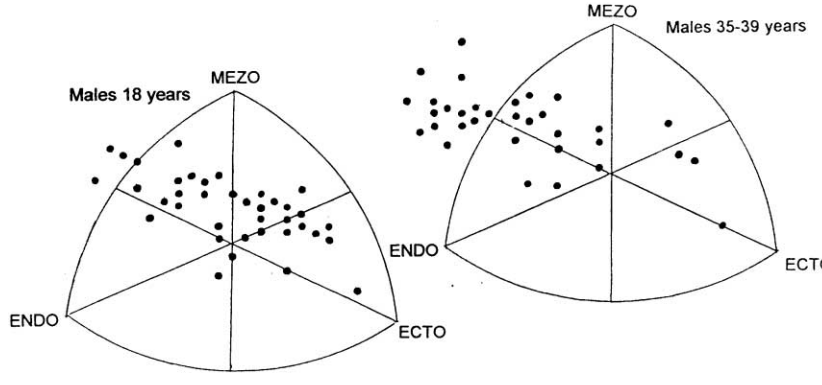

Fig. 2. Changes in somatotypes from 18 to 35–39 years of age in males.

supposed increase of weight, fat and muscles and a shift on the triangle area towards its NW border (using geographical terms as if we are locating a point on a map). The term »mesomorph-endomorph« remains unchanged.

Changes in males: When we round up individual components to full numbers at the age of 18 years we get 3-5-3 called »balanced mesomorph« located close to the center of the triangle. At the age of 35–39 years the mean somatotype with rounded components looks 5-6-2. Muscles, fat and bones increased and the new somatotype moved on the surface of the triangle to its NW border (the distance is nearly the same as in the case of females). The change brought also a new name: »endomorph-mesomorph«.

In both sexes a similar, nearly parallel shift, took place throughout the years on the somatograph. It looks like if the somatotypes are getting heavy due to incorporating fat, muscle and bone to their substances. Mesomorphic and endomorphic components are getting more power with age in their somatotypes on behalf of the ectomorphic one.

Discussion

The advantage of our study is that we compare measurements and somatotypes of the same subjects at the age of 18 and 35–39 years.

Growth in height in most individuals ends at the age of 18 years, but the widths, depths and circumferences increase with age, the body is becoming vigorous and ripe. Hrdlicka[15] observed that head circumference, nose and ears increase in size during life. These traits probably increase in later life. Measurements on ears and noses were not included in our study.

Extreme types (thin and obese) are getting their final profile in the third decade of life. This topic would deserve an individual analysis taking into consideration individual lifestyle, profession, health state and nutrition. In the meantime we have to accept the collective way of treating the data of a group of relatively healthy individuals from Prague 3, with professions similar to the rest of the city, with slightly better education. The author is well aware of the fact, that the results found in the Prague sample, though they may be similar in upper middle social class in most contemporary central European cities, would probably differ from a group of other socio-economic strata and in another place and at another time.

It has been shown that females had in comparison with males thicker skin folds, more fat in their bodies, a broader pelvis in relation to stature and in relation to shoulder width. This was expected. Surprisingly females had also their relative head circumference (in relation to stature) greater than males.

Whereas we have always heavily criticized the idea that growth of a child may be viewed as if pumping a rubber figure, it seems that this model expresses beautifully what happens in the human body in the years after it had reached adulthood.

Conclusions

Eighteen body measurements are presented of 56 females and 47 males from the Prague longitudinal study at the age of 35–39 years and the results are compared with those from the age of 18 years of the same individuals.

Comparison with the contemporary Czech adult population showed that both studies may be considered as close to each other. Significant differences in females were found in height, femur width, supra iliac skin fold and waist girth, our group having higher means; in males in head circumference and skin folds, our group having higher means.

Females at the age of 35–39 differ on the average from the 18 years old significantly in all measurements with the exception of height, sitting height, head measurements, humerus width and 2 skin folds on the arm and in the percentage of total amount of fat in the body. In males, all measurements besides sitting height and humerus width increased significantly.

Changes in somatotypes with age were also studied. Average somatotypes moved in the Sheldon's triangle in both sexes with age in the NW direction (taken geographically). In both sexes the change concerns an increase of the endomorph and mesomorph components on behalf of the ectomorph one. Somatotype changes not only in the course of growth and development[16] but also after adulthood had been reached. Changes in the BMI in both sexes are in favor of this observation. This change is typical for the city dwellers with limited sport activity on the average. A few individuals from the group of 35–39 year olds trespassed the threshold of BMI 30 (11 per cent females and 18 per cent males) which means that they were objectively obese and thus at risk of cardiovascular disease.

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ŠTO SE DOGODI S DJECOM KADA ODRASTU?
Kako se ljudsko tijelo mijenja nakon 18. godine života

SAŽETAK

Ova studija odgovara na pitanje kako se ljudsko tijelo mijenja tijekom dva uzastopna desetljeća nakon što je rast u visinu završen. U studiju su uključene stotinu i tri osobe (56 muškaraca i 47 žena) koje je znanstveni tim antropometrijski longitudinalno pratio (18 mjera) od rođenja do njihove 18. godine, te ponovno između njihove 35 i 39 godine života. U sklopu studije korišteni su i Carter-Heathovi somatotipovi. Rezultati istraživanja dobne skupine od 35 do 39 godina uspoređeni su s standardom za Češku (Bláha, 1986) kao i s nalazima dobivenim u 18-godišnjaka. Srednje vrijednosti svih mjera u oba spola pokazale su porast s dobi (uz iznimku visine tijela u žena). Relativne mjere i indeksi, koji su izračunati samo u skupini 35–39-godišnjaka bili su prosijeku veći u muškaraca nego u žena s izuzetkom relativnog opsega glave, širine zdjelice, postotka širine zdjelice u odnosu na biakromijalnu širinu, sume kožnih nabora, te ukupnog postotka tjelesne masti. Muškarci kao i žene u pravilu su u dobi od 35–39 godina u odnosu na dob od 18 godina imali veću tjelesnu masu, veću masu mišića, kostiju, te masnog tkiva, što je našlo svoj odraz u pomaku ektomorfnog somatotipa prema endomorfnoj i mezomorfnoj komponenti.