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THE DISTRIBUTION OF SUBCUTANEOUS FAT IN PREPUBESCENT BOYS AND IN THOSE ENTERING PUBERTY

ABSTRACT: From 1993 to 1994 a total of 763 boys between the ages of 7 and 13 were examined in Prague basic schools. Principal anthropometric and functional characteristics were observed with the goal of summarizing the growth and developmental trends of somatic parameters in prepubescent boys and those entering the puberty growth spurt. Among other aims we focused on the study of the development of fourteen skin folds and the changes in the distribution of subcutaneous fat during this time. For these purposes we used the centrality indices according to Pařízková (1962) and the calculation of the natural logarithms of the ratio of skin fold thickness according to Ulbrichová (1992). The percentage of body fat was also observed according to the methods of Pařízková (1962). It was determined that, on average, the skin fold thickness for boys in this development stage increases. However, the developmental trend fluctuates considerably. Often we observed stagnation in the further growth of samples, most relevantly their moderate decrease, typical for the time period at the beginning of the puberty growth spurt. During our research the main growth appeared in skin folds on the chest, above the ridge of the hip bone and on the stomach. The distribution indices of subcutaneous fat supported this finding. While up to age 5 the storage of subcutaneous fat on limbs (triceps, thighs) prevails in proportion to the trunk for boys, the situation begins to change in prepubescence. The ratio of skin fold thickness gradually evens out and the distribution of fat moves in the centripetal direction. The centrality indices reveal a process of greater storage of subcutatneous fat on the trunk characteristic for the given age. Natural logarithms of the ratio of skin fold thickness, assessing the situation at a given age, draw attention to the lasting, greater thickness of skin folds on the limbs which gradually reaches a balanced state. However, we cannot reliably confirm changes in this ratio in boys before 15 years of age, that is when a greater amount of subcutaneous fat is clearly proved to be on the trunk.

KEY WORDS: Skin fold – Distribution of subcutaneous fat – Prepubescence – Onset of puberty – Boys

INTRODUCTION

The growth and development of children is an ongoing, continuous process which in normal conditions characterizes the entire childhood period. These two basic, mutually linked attributes of every living organism, however, are not expressed with the same intensity in humans. On the basis of growth and development specifications childhood is divided into particular periods of development. Each of these periods has its own characteristics. One of the somatic and functional characteristics is the type of distribution of subcutaneous fat with which the thickness development in individual skin folds is connected. The following work observes these characteristics in prepubescent boys.

MATERIAL AND METHODS

The study is made up of 763 boys from the ages of 7 to 13 years between 1993–1994 at Prague basic schools. On the basis of their age, expressed in the decimal system (according to the IBP principles, 1969), these boys were chronologically divided into 14 age groups by the half year. This division made it possible to analyze more precisely and in a more detailed manner the changes in the distribution of fat of the defined age group. The table (*Table 1*) gives the number of probands in individual age categories in our study.

TABLE 1. Division of age categories and the number of probands.

Age category	No.
7.00–7.49	18
7.50–7.99	33
8.00–8.49	44
8.50–8.99	61
9.00–9.49	57
9.50–9.99	64
10.00–10.49	64
10.50–10.99	61
11.00–11.49	68
11.50–11.99	51
12.00–12.49	52
12.50–12.99	62
13.00–13.49	64
13.50–13.99	64
Total	763

Anthropometric measures were applied before noon using standard methodology (Martin, Saller 1957; Riegrová, Ulbrichová 1993) on the right side of the body. In addition to the basic growth characteristics of the group (body height and body mass), we also determined the thickness of fourteen skin folds (caliper, Best trademark) and counted the percentage of body fat according to Pařízková's modification method (ANTROPO software, version 4.0.1). Some indices, characterizing ratios in the distribution of subcutaneous fat on the trunk and limbs, were further established from the measured value of the skin fold. Namely, these were the centrality indices (Pařízková 1962) and the natural logarithms of the ratio of skin fold thickness (Ulbrichová 1992).

Summary of measured skin folds: on the cheek, under the chin, on the chest I (in *reg. mammalis*), on the chest II (on the tenth rib, in *reg. hypochondrica*), on the back side of the arm (above the *m. triceps brachii*), under the shoulder blade (in *reg. subscapularis*), above the ridge of the hip bone (in *reg. suprailiacalis*), on the stomach, on the thigh (above the quadriceps muscle of the thigh, in *reg. femoris anterior*), above the patella, on the calf I (under *fossa poplitea*), on the calf II (in *reg. cruris posterior*), on the front side of the arm (above the *m. triceps brachii*), on the inner side of the forearm.

In the first case we used the centrality indices Nos.2 and 3 for the designated type of subcutaneous fat distribution:

No. 2 = skin folds on the chest I + under the shoulder blade + on the stomach + suprailiac + on the chest II/the skin fold on the cheek + under the chin + above the triceps + above the patella + under *fossa poplitea*

No. 3 = skin folds under the shoulder blade + on the stomach + suprailiac/skin fold above the triceps + above the patella + under *fossa poplitea*

The natural logarithm of the ratio of skin fold thickness was calculated on the basis of the following relationships:

I1 = In (skin fold under the shoulder blade / skin fold above the triceps)

I2 = In (skin fold suprailiac/skin fold above the triceps)

I3 = In (skin fold under the shoulder blade/ skin fold on the thigh)

I4 = In (skin fold suprailiac/ skin fold on the thigh)

The division of the type of subcutaneous fat was then assessed on the basis of the following relationships:

centrifugal (peripheral) type	$I < -0.1$
centripetal type	$I > 0.1$
balanced type	$-0.1 > I > 0.1$

RESULTS AND DISCUSSION

The thickness of individual folds grew for almost the entire period of observation. Average half-year increases, however, were not even and in the majority of cases not especially significant (with some exceptions statistical significance was not proved).

The skin folds on the cheek and under the chin increased moderately in most age categories. Relatively often, however, we recorded their moderate decrease. These were: in the age group 9.00–9.49 years (–3.6 mm), 11.00–11.49 years (–2.3 mm), also in both 12-year-old age groups (–2.3 mm and –7.6 mm) and in the age group 13.50–13.99 years (–1.5 mm) (*Table 2*).

The skin fold on the chest I providing information on the amount of subcutaneous fat in the upper part of the chest (*reg. mammalis*) and the skin fold on the chest II (in *reg. hypogastrica*) also fluctuated in their development. In our study we recorded the greatest average growth in the ages of 10.00–10.49. The decrease in thickness in these skin folds was typical at the beginning of the growth spurt of the chest; in ages 10.00–11.99 to the final observed age group (13.50–13.99), average half-year increases are of a negative value (*Table 3*).

In skin folds on the back side of the arm (above the *m. triceps brachii*) and under the shoulder blade (in *reg. subscapularis*) it is not possible to describe reliably a uniform trend of development up to the age of 12. The half-year differences of average values are also significantly uneven. In our study from the age of 12 there

TABLE 2. Thickness of the skin fold on the cheek and under the chin (in mm) – boys.

Age years		Skin fold cheek		Skin fold chin	
	n	x	SD	x	SD
7.0–7.49	18	5.53	1.62	5.17	2.36
7.5–7.99	33	6.20	1.71	4.76	1.68
8.0–8.49	44	6.60	1.98	5.23	2.16
8.5–8.99	61	6.24	1.97	5.22	2.19
9.0–9.49	57	6.53	1.90	5.46	2.16
9.5–9.99	64	6.69	2.14	5.98	2.64
10.0–10.49	64	0.07	2.47	6.11	2.87
10.5–10.99	61	7.32	2.52	6.56	3.26
11.0–11.49	68	7.09	2.20	6.65	3.21
11.5–11.99	51	7.64	3.34	6.42	3.32
12.0–12.49	52	7.41	2.67	6.58	3.81
12.5–12.99	62	6.65	2.02	5.45	2.73
13.0–13.49	64	6.91	2.06	5.23	2.58
13.5–13.99	64	6.76	1.93	5.17	2.65

TABLE 3. Thickness of the skin fold on the chest I and II (in mm) – boys.

Age years		Skin fold chest I		Skin fold chest II	
	n	x	SD	x	SD
7.0–7.49	18	8.14	6.38	4.61	3.81
7.5–7.99	33	5.88	3.77	3.55	1.57
8.0–8.49	44	5.97	5.24	4.19	3.67
8.5–8.99	61	5.72	4.41	4.25	3.79
9.0–9.49	57	5.73	4.51	4.15	2.80
9.5–9.99	64	6.61	5.16	4.84	3.55
10.0–10.49	64	6.58	4.94	5.11	3.95
10.5–10.99	61	8.53	7.37	6.29	5.39
11.0–11.49	68	8.68	6.74	5.96	4.58
11.5–11.99	51	8.04	6.62	5.89	4.34
12.0–12.49	52	7.61	5.96	6.34	4.62
12.5–12.99	62	7.16	4.20	5.84	3.41
13.0–13.49	64	6.98	5.27	6.85	5.06
13.5–13.99	64	5.85	4.21	6.36	4.85

TABLE 4. Thickness of the skin fold above the triceps and under the shoulder blade (in mm) – boys.

Age years		Skin fold triceps		Skin fold shoulder blade	
	n	x	SD	x	SD
7.0–7.49	18	8.64	4.38	4.97	3.53
7.5–7.99	33	8.26	2.66	3.80	1.70
8.0–8.49	44	8.51	4.45	4.28	2.69
8.5–8.99	61	8.70	4.38	4.57	3.35
9.0–9.49	57	8.61	4.05	4.49	2.95
9.5–9.99	64	9.70	4.08	5.35	3.40
10.0–10.49	64	9.67	4.59	5.72	4.57
10.5–10.99	61	10.71	5.72	6.25	5.23
11.0–11.49	68	10.86	5.47	6.93	6.52
11.5–11.99	51	10.63	5.59	6.53	5.74
12.0–12.49	52	11.16	5.76	7.42	6.67
12.5–12.99	62	10.40	4.51	6.35	3.74
13.0–13.49	64	10.42	5.29	7.19	5.59
13.5–13.99	64	9.88	5.22	7.21	5.03

TABLE 5. Thickness of the suprailiac skin fold and of the skin fold on the belly (in mm) – boys.

Age years		Skin fold suprailiac		Skin fold belly	
	n	x	SD	x	SD
7.0–7.49	18	8.06	7.03	8.47	6.35
7.5–7.99	33	5.53	2.59	5.94	3.67
8.0–8.49	44	7.18	7.24	7.66	6.91
8.5–8.99	61	7.98	7.53	8.21	7.55
9.0–9.49	57	7.61	6.13	7.55	6.64
9.5–9.99	64	9.34	7.51	9.23	7.30
10.0–10.49	64	9.55	8.28	9.99	7.53
10.5–10.99	61	10.75	9.06	11.75	9.21
11.0–11.49	68	11.93	9.74	12.62	10.27
11.5–11.99	51	10.90	8.90	11.95	8.44
12.0–12.49	52	12.29	9.82	13.32	10.56
12.5–12.99	62	11.25	6.79	11.58	7.92
13.0–13.49	64	12.20	8.71	13.09	10.83
13.5–13.99	64	11.69	8.09	11.59	8.13

TABLE 6. Thickness of the skin fold on the thigh and above the patella (in mm) – boys.

Age years		Skin fold thigh		Skin fold patella	
	n	x	SD	x	SD
7.0–7.49	18	15.61	6.12	5.86	2.34
7.5–7.99	33	12.94	4.07	5.80	2.73
8.0–8.49	44	14.40	6.68	5.75	3.08
8.5–8.99	61	14.65	6.93	6.53	4.30
9.0–9.49	57	13.43	6.16	5.55	2.25
9.5–9.99	64	16.07	6.90	6.84	3.17
10.0–10.49	64	15.45	6.69	6.38	3.11
10.5–10.99	61	16.95	7.85	7.36	3.94
11.0–11.49	68	18.19	7.45	7.09	3.85
11.5–11.99	51	17.34	6.98	7.38	4.27
12.0–12.49	52	18.24	6.96	7.21	3.50
12.5–12.99	62	17.04	5.83	6.88	3.16
13.0–13.49	64	17.44	7.60	7.72	4.94
13.5–13.99	64	13.23	6.79	7.30	3.98

TABLE 7. Thickness of the skin fold on the calf I and II (in mm) – boys.

Age years		Skin fold calf I		Skin fold calf II	
	n	x	SD	x	SD
7.0–7.49	18	3.50	2.14	13.08	5.15
7.5–7.99	33	3.06	1.50	11.67	3.20
8.0–8.49	44	4.09	2.24	12.72	4.70
8.5–8.99	61	4.02	2.55	12.33	4.11
9.0–9.49	57	4.09	2.19	12.07	4.15
9.5–9.99	64	4.48	2.42	13.66	4.50
10.0–10.49	64	4.94	2.82	13.52	4.87
10.5–10.99	61	5.61	3.41	14.94	5.37
11.0–11.49	68	5.71	3.44	15.22	5.57
11.5–11.99	51	5.75	2.89	14.85	4.74
12.0–12.49	52	5.98	3.24	16.08	5.35
12.5–12.99	62	5.56	2.94	15.94	5.47
13.0–13.49	64	6.14	3.59	16.26	5.98
13.5–13.99	64	6.09	3.31	15.45	5.22

began to be seen a stagnation in further growth to a moderate decrease of the subcutaneous fat layer in these regions, conditioned by the puberty growth spurt and by an intensified growth of the segments of the upper limbs in terms of length, which was linked with specific distribution of subcutaneous fat in boys in this time period (*Table 4*).

The suprailiac skin fold and the skin fold on the stomach showed identical trends of development. In the majority of age groups we found positive increases, meaning the growth of these skin folds. First of all in 9-year-olds and from 12-year-olds onwards, certain alternation of half-year periods of moderate growth in these skin folds and subsequent stagnation to moderate regression took place. However, the statistical significance of these differences of average values, as in the previous cases, was not confirmed (*Table 5*).

The average half-year increases of the skin folds on the thigh (in *reg. femoris anterior*) were the greatest in the age group 9.50–9.99 (2.64 mm). In this case we proved the significance of this increase to a level of 5%.

In the skin folds above the patella we recorded almost regularly flucutating trends of development in our group of boys. There were alternating half-year increases and decreases of thickness in this fold. We recorded the greatest average growth, 1.29 mm, to a significant 5% level, in the age group 9.50–9.99. A statistically significant difference in the average value was not confirmed in the other age groups.

The development of skin folds on the calf I (under *fossa poplitea*) and on the calf II (in *reg. cruris posterior*) was not clear. The differences of average values in the individual half-year age categories, however, were not considerable and were for the most part statistically insignificant (*Table 7*).

The average values of skin folds on the front side of the arm (above *m. triceps brachii*) and skin fold on the inner side of the forearm changed very little during the observation period. Positive increases were not especially great. Moderate regression in some age groups is, in terms of an average, regarded as a certain stagnation of growth in these parameters (*Table 8*).

In all ages observed the percentage of fat in our boys increased from 9% in 7-year-olds to 12.4% in the age group 13.00–13.49. In the ages 13.50–13.99, thus at the beginning of the puberty growth spurt, we recorded a moderate drop (about 5%). The value of average individual increases in the half years was not significant in any age group.

The centrality index X2 documents the ratio in the division of fat on the chest in relation to the limbs and head. The average values of this index are positive in our study and increase, thus supporting the gradual moderate expansion of the fat layers on the trunk.

Index X3 presents the ratio of skin folds on the trunk and limbs without regard to the thickness of the skin fold on the cheek and under the chin. In this case the average positive values of the index and their moderate, even growth

TABLE 8. Thickness of the skin fold above the biceps and on the inner side of the forearm (in mm) – boys.

Age years		Skin fold biceps		Skin fold inner forearm	
	n	x	SD	x	SD
7.0–7.49	18	3.92	1.98	4.92	2.63
7.5–7.99	33	3.21	1.35	3.92	1.71
8.0–8.49	44	3.88	2.89	4.57	2.63
8.5–8.99	61	3.81	2.64	4.81	2.53
9.0–9.49	57	3.84	2.35	4.55	2.05
9.5–9.99	64	4.45	2.72	5.14	2.24
10.0–10.49	64	4.33	2.85	5.22	2.28
10.5–10.99	61	5.13	3.69	5.66	3.03
11.0–11.49	68	5.35	3.27	5.87	2.88
11.5–11.99	51	5.29	3.17	5.50	2.79
12.0–12.49	52	5.20	3.44	5.53	2.73
12.5–12.99	62	4.66	2.82	5.40	2.75
13.0–13.49	64	4.57	3.25	5.47	3.22
13.5–13.99	64	4.03	2.70	4.53	2.72

TABLE 9. Percentage of fat according to Pařízková and centrality indices – boys.

Age years		% fat (Pařízková)		X 2	X 3
	n	x	SD	x	x
7.0–7.49	18	10.31	4.30	0.62	0.72
7.5–7.99	33	8.84	2.90	0.53	0.63
8.0–8.49	44	9.34	4.35	0.56	0.67
8.5–8.99	61	9.71	4.20	0.59	0.70
9.0–9.49	57	9.64	4.08	0.58	0.71
9.5–9.99	64	10.81	4.44	0.62	0.73
10.0–10.49	64	10.92	4.68	0.64	0.77
10.5–10.99	61	12.00	5.13	0.67	0.79
11.0–11.49	68	12.30	5.13	0.69	0.82
11.5–11.99	51	12.25	5.15	0.69	0.81
12.0–12.49	52	12.66	5.22	0.73	0.86
12.5–12.99	62	12.01	4.23	0.73	0.84
13.0–13.49	64	12.41	4.75	0.80	0.91
13.5–13.99	64	11.96	4.38	0.79	0.90

TABLE 10. Values of natural logarithms of the ratio of skin fold thickness – boys.

Age years		I 1	I 2	I 3	I 4
	n	x	x	x	x
7.0–7.49	18	–0.25	–0.09	–0.53	–0.37
7.5–7.99	33	–0.35	–0.19	–0.54	–0.39
8.0–8.49	44	–0.30	–0.14	–0.53	–0.36
8.5–8.99	61	–0.31	–0.11	–0.53	–0.34
9.0–9.49	57	–0.29	–0.11	–0.49	–0.31
9.5–9.99	64	–0.28	–0.09	–0 01	–0.30
10.0–10.49	64	–0.27	–0.09	–0.48	–0.29
10.5–10.99	61	–0.27	–0.07	–0.48	–0.28
11.0–11.49	68	–0.26	–0.03	–0 01	–0.27
11.5–11.99	51	–0.25	–0.04	–0.48	–0.27
12.0–12.49	52	–0.22	–0.01	–0.46	–0.25
12.5–12.99	62	–0.23	0.00	–0.46	–0.23
13.0–13.49	64	–0.19	0.03	–0.43	–0.22
13.5–13.99	64	–0.16	0.04	–0.39	–0.19

confirm the prevalence of fat stored on the trunk in comparison to the limbs in this time period and the beginning of the relative reduction of the skin folds on the limbs. This finding confirms the generally recognized trend that the tendency for greater storage of fat on the limbs begins to change after the fifth year of a child's life and fat slowly begins to be stored predominantly on the trunk. However, it is not possible to record a more significant reduction of the skin folds on limbs before the time of the puberty growth spurt (*Table 9*).

For further evaluation of the distribution of subcutaneous fat during the ontogenesis and the assessing of its type, we used, in addition to the centrality index, the natural logarithms of the ratio of skin fold thickness on the trunk and limbs. The average values for all four indices used (I1–I4) changed very insignificantly in the ages observed, which could have been conditioned by the multifaceted character of the observation. Because this method uses a modified ratio of two skin folds in the relation of the trunk/limbs for the calculation of index value (the natural logarithms convert the value of the ratio of skin folds to the numerical form of the index), we seemingly obtained different results than those of the centrality index. The average values of indices I1, I3 and I4 in all observed age categories were lower than – 0.1 and thus signaled greater storage of subcutaneous fat on limbs in comparison to the trunk, thus the centrifugal type of fat distribution. The average values of index 2 fluctuate in intervals between –0.1 to +0.1 and thus rather indicate the balanced proportion of fat on the limbs and trunk. In all cases the average values of the index increased with age, yet the distribution of fat of the centrifugal type dominated to the end of the observation period (up to age 13). In these conclusions we agree with Ulbrichová's findings (1992), which further indicate that the tendencies for the centripetal type of distribution of subcutaneous fat were apparent in boys after the age of 15, in accordance with the findings that the predominant location for the storage of fat in adult men is the region above the ridge of the hip bone (*Table 10*).

While the centrality indices inform of changes in the distribution of subcutaneous fat during the course of ontogenesis, natural logarithms of the ratio of skin fold thickness provide information on the actual situation at the given age. On the whole, it follows from this finding that in our study of boys in the observed age categories the amount of fat on the limbs prevailed but with age greater storage of fat was transferred to the trunk region. Even though natural logarithms of the ratio of skin fold thickness assessed the distribution of fat as centrifugal, the tendency of development gradually moved in the centripetal direction.

The amount of subcutaneous fat changes in the course of the ontogenetical development of children. Its distribution changes in various regions. Thus the distribution type of subcutaneous fat becomes the characteristic mark in individual periods of development in the childhood years.

For boys the ratios of stored subcutaneous fat begin to change during prepubescence. The centrifugal (peripheral) type, characteristic for the earlier stages of childhood, transfers to the centripetal type. This means that subcutaneous fat in boys begins to be stored on the trunk as early as prepubescence. The change of this ratio is confirmed by the centrality indices according to Paøízková (1962), which are capable of recording the distribution of subcutaneous fat during the course of ontogenesis. The method of natural logarithms of the ratio of skin fold thickness only provides information on the ratio of subcutaneous fat in the given moment and does not follow the development trend.

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