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Development of Centrality Indices of Subcutaneous Fat During Growth

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A B S T R A C T

Changes of fat distribution were followed up in Czech and Slovak children from 1.5 to 15 years of age, using centrality indices, which relate the values of skinfolds on the trunk to the skinfolds on the extremities, head and neck. Up to 5 years of age, subcutaneous fat was deposited relatively more on the extremities, head and neck than on the trunk, which was expressed by lower values of the centrality indices. After the age of 5 years, the accumulation of subcutaneous fat was greater on the trunk, which was also expressed by higher values of the centrality indices. The comparison of the individual indices revealed in both genders a relatively higher amount of subcutaneous fat on the trunk in boys until 12 years of age. During puberty subcutaneous fat over triceps and on the forearm was reduced. In girls the deposition of the subcutaneous fat was relatively greater at different sites of the trunk than in boys, with the exception of the age of 14–15 years. The deposition of subcutaneous fat was greater on the trunk than on the head (cheek) and on the extremities in Czech compared to Slovak children, except for 12-year-old girls. During the period between the fifties and the seventies of the last century, in Czech children, especially in girls, the deposition of subcutaneous fat on the trunk was relatively smaller than on other parts of the body surface, which was expressed by the reduction of the centrality indices. Index I2 was therefore considered as the most valuable for the characterization of fat distribution on the body surface.

***Key words**: growth and development, subcutaneous fat, centrality indices*

Introduction

During human ontogeny, the amount of fat in the organism does not change only with regard to its absolute amount but also its distribution – i.e. subcutane-

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ous or visceral fat. Along with that, the fat distribution at different sites of body surface undergoes significant changes. This concerns both its deposition on the trunk and on the extremities[1–7].

The effect of age and gender in this respect is significant[8–10]. The relationships between skinfold thickness at different sites of the body surface[11] are best characterized by indices, calculated as relationships between various skinfolds measured on the trunk and on the extremities[12–14].

Various types of fat distribution, e.g. the android, »apple« distribution of fat, and the gynoid, »pear« type, were also evaluated with the help of the waist and hip circumference ratio (W/H)[15–20]. The »apple« deposition of fat on the trunk is most often accompanied by deviations of the lipid and glucose metabolism as first shown by Vague[21,22]. Gerard et al.[23], who evaluated body fat assessed with the help of deuterium oxide and bioimpedance analysis (BIA). Ducimetiere et al.[24] analyzed in adult men the relationship between fat distribution, characterized by the ratio of trunk and thigh skinfolds, and coronary atherosclerosis. Therefore, the evaluation of fat distribution can be used also for the prediction of health risks such as atherosclerosis and other cardiovascular diseases, diabetes etc.[24,25].

Previous measurements of subcutaneous fat development[11,25,27] showed an absolute and relative increase of depot fat on the trunk, but a relative decrease on the extremities in boys during puberty. In girls the situation was similar with regard to the skinfolds on the trunk, but subcutaneous fat on the extremities remained unchanged. This indicated a change in the distribution of subcutaneous fat, which was different according to gender. Therefore, the mentioned ontogenetic changes in both girls and boys were analyzed also using the indices relating various combinations of skinfolds measured on the trunk on the one hand, and on the extremities, head and neck on the other hand. Finally, secular changes of these indices were evaluated using the measurements of skinfold thickness in children during the fifties (1957–9) and the seventies (1976–8) of the last century. Because certain environmental differences between the Czech and Slovak Republic (which formed the former Czechoslovakia), the results were evaluated separately for these two nationalities.

Materials and Methods

The results of the measurement of ten skinfolds in Czech and Slovak children from 1.5 to 15 years of age (Hajniš 1990)[26] were used for the calculation of the centrality indices. In total, the measurements were made in 20 statistical (three degree) selected localities (13 in the Czech, and 7 in the Slovak Republic). Initially more than 11,000 subjects were examined, and the centrality indices in 10,661 subjects during the years 1976–8 were evaluated. The senior author implemented all skinfold measurements.

The ratio of probands according to gender and age was comparable (see Table 1). The ratio of Czech and Slovak children represented approximately 2:1, which also corresponded to total number of inhabitants in both regions.

The following 10 skinfolds (using a modified Best caliper) were investigated according Allen et al.[28] and Pařízková[9,29]:

– 1: regio parotideomasseterica/cheek;
– 2: regio submentalis/ chin;
– 3: regio mammalis/ chest;
– 4: regio hypochondriaca/ subaxillar;
– 5: regio lateralis/ suprailiac;
– 6: regio subscapularis/ subscapular;
– 7: regio umbilicalis/ paraumbilical;
– 8: regio brachii post./ triceps;
– 9: regio femoris ant./ thigh;
–10: regio cruris post./ calf.

Three centrality indices were evaluated:

I_1=100 x SF subscapular / SF triceps;

I_2=100 x Σ SF chest + SF subaxillar + SF suprailia + SF paraumbilical + SF;

subscapular / Σ SF cheek + SF chin + SF triceps + SF thigh + SF calf;

I_3=100 x *SUMA* SF subscapular + SF subaxillar/*SUMA* SF triceps + SF calf.

Average values and SD of indices in one-year age groups were calculated and are given, separately for both genders and also separately for Czech and Slovak children. The age intervals were one year, with the exception of the first age group, which included probands from 18 to 24 months of age.

Results and Discussion

Developmental changes of the centrality indices

The development of centrality indices during early and later childhood are given in Figures 1–3. Age changes of the indices were similar for both nationalities: after an initial reduction of the average values, which were due to a greater accumulation of fat on the extremities, head and neck as compared to the trunk, an increase was apparent later. From the age of 5 years the accumulation of fat was greater on the trunk, and the values of the indices increased. However, some gender differences were apparent in both Czech and Slovak children. From the age of 5 years, the subcutaneous fat layer on the trunk was relatively smaller in Slovak as compared to Czech children. This difference appeared in Slovak girls only up to 12 years of age, than the average values seem to be higher than in Czech girls (Figures 1–3).

In all age categories, the amount of fat was relatively greater in girls. In the majority of cases, the average values of the

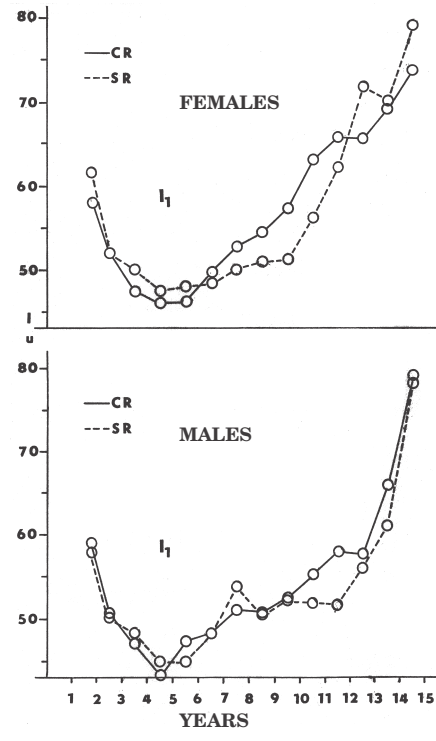

Fig. 1. Age changes of centralization index I_1 in Czech and Slovak children.

indices in Czech children of the same age and gender were significantly higher (p at least 99%) than in Slovak children. There were also significant differences among age groups, e.g. in 8–9-years-old girls the value of the t-test evaluating the difference between Czech and Slovak girls was 4.399, $p<0.0005$, but in the age group 1.5–2 years it was only 0.576, $p< 0.25$. When comparing the average values of the individual indices, gender differences were apparent especially after 10 years of age when they were more marked. Thus the amount and distribution of fat were a significant gender characteristic already before puberty. In 14-years-old Czech children index I_2 t_{503} = 5.216, $p< 0.0005$, then in 10–11-years old children

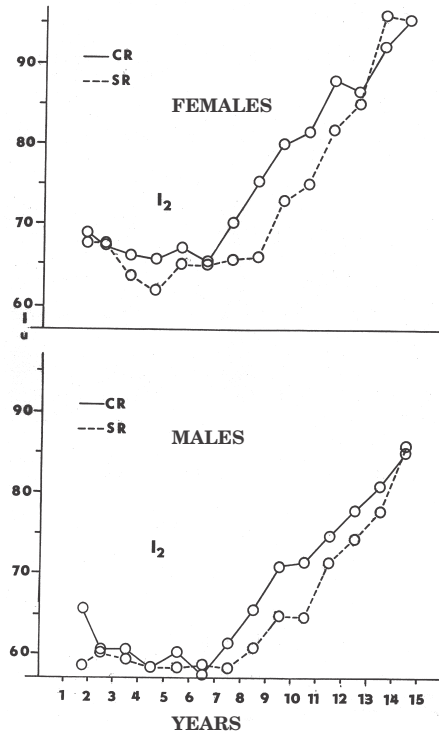

Fig. 2. Age changes of centralization index I_2 in Czech and Slovak children.

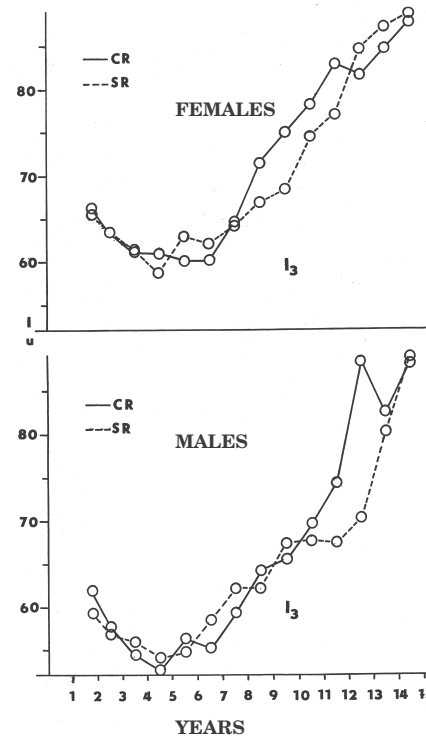

Fig. 3. Age changes of centralization index I_3 in Czech and Slovak children.

TABLE 1
NUMBER OF EXAMINED PROBANDS IN THE AGE CLASSES

Age class (years)	ČSR		ČR		SR	
	Boys	Girls	Boys	Girls	Boys	Girls
$1^{1/2}$–2	222	213	106	112	116	101
2–3	367	359	230	225	137	134
3–4	349	333	226	212	123	121
4–5	324	324	198	188	126	136
5–6	362	363	236	236	126	127
6–7	423	445	283	292	140	153
7–8	444	433	288	273	156	160
8–9	385	409	236	261	149	148
9–10	400	388	256	245	144	143
10–11	432	429	272	278	160	151
11–12	407	395	271	255	136	140
12–13	407	418	254	266	153	152
13–14	413	424	275	279	138	145
14–15	404	389	253	252	151	137
Total	5,339	5,322	3,384	3,374	1,955	1,948

TABLE 2
DEVELOPMENT OF CENTRALIZATION INDEX 1 (SF SUBSCAPULAR TO SF TRICEPS) OF BOYS AND GIRLS BY AGE

Age class (years)	ČR				SR			
	Boys		Girls		Boys		Girls	
	X	SD	X	SD	X	SD	X	SD
1½–2	59.07	18.66	59.07	16.30	58.13	17.05	61.49	20.52
2–3	50.79	12.20	52.89	14.94	50.08	13.14	52.25	13.95
3–4	47.13	21.62	47.78	11.92	48.38	12.85	50.16	11.42
4–5	43.27	11.85	46.65	13.09	45.08	12.40	47.68	12.18
5–6	46.70	13.37	46.81	15.06	45.04	12.38	48.33	13.58
6–7	47.55	13.86	49.90	27.62	47.38	13.31	48.61	18.09
7–8	51.17	15.15	52.75	20.87	54.13	17.98	50.22	21.72
8–9	50.92	16.43	54.67	28.53	50.51	16.51	51.19	17.38
9–10	52.53	17.27	57.37	23.04	53.12	16.63	51.63	18.39
10–11	55.18	18.01	63.18	32.77	52.49	18.89	56.35	23.70
11–12	58.41	18.09	66.70	37.56	52.02	17.22	62.44	24.88
12–13	57.92	20.21	66.49	19.93	56.32	20.92	71.95	21.63
13–14	67.89	26.34	69.27	22.84	63.86	23.97	70.36	20.36
14–15	79.18	25.88	74.36	23.79	77.76	29.05	79.17	37.01

TABLE 3
DEVELOPMENT OF CENTRALIZATION INDEX 2 (5 SF OF THE TRUNK TO 5 SF OUT OF TRUNK) OF BOYS AND GIRLS BY AGE

Age class (years)	ČR				SR			
	Boys		Girls		Boys		Girls	
	X	SD	X	SD	X	SD	X	SD
1½–2	66.04	22.25	68.95	15.04	58.45	10.67	67.70	16.43
2–3	60.53	12.99	67.17	12.83	60.12	11.86	67.77	16.17
3–4	60.49	13.00	66.05	14.96	59.20	12.86	63.50	11.54
4–5	58.28	12.83	65.51	13.58	58.24	11.28	61.78	18.70
5–6	61.16	12.64	67.71	18.63	58.22	13.92	65.13	15.10
6–7	57.48	16.17	65.25	19.01	59.92	19.74	64.91	18.60
7–8	61.37	16.97	70.42	23.01	58.37	13.93	65.67	20.52
8–9	65.92	22.00	76.41	26.76	60.86	18.74	65.94	20.77
9–10	70.86	23.64	80.13	24.97	65.12	19.78	73.23	24.99
10–11	71.36	25.86	81.59	24.80	64.86	17.63	75.21	22.71
11–12	74.90	25.86	88.43	29.79	71.46	25.03	82.00	20.30
12–13	78.07	25.30	86.56	22.37	74.61	21.82	86.09	23.86
13–14	81.63	22.58	91.89	22.28	77.97	19.12	96.00	22.95
14–15	85.10	20.99	95.48	23.59	86.08	21.33	95.40	23.23

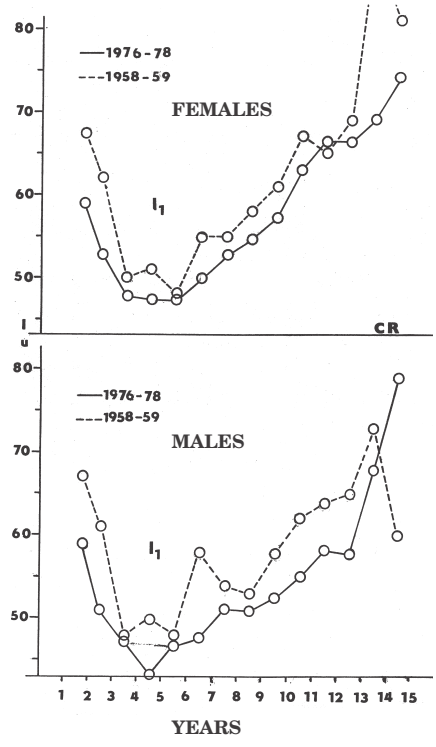

Fig. 4. Comparison of age changes of centralization index I_1 in the fifties and seventies in Czech children.

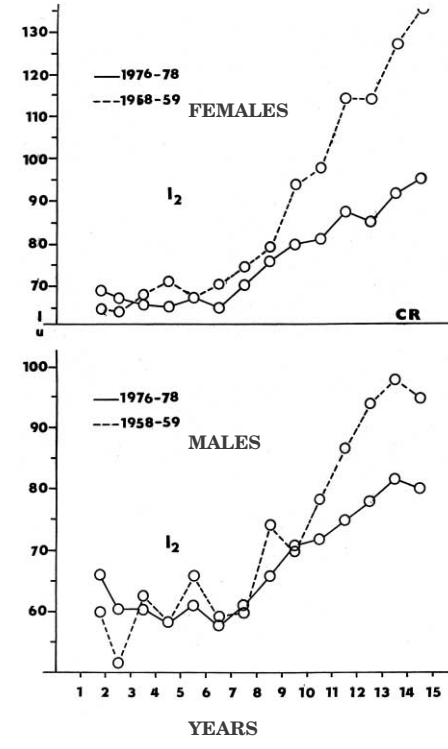

Fig. 5. Comparison of age changes of centralization index I_2 in the fifties and seventies in Czech children.

TABLE 4
DEVELOPMENT OF CENTRALIZATION INDEX 3 (SF SUBSCAPULAR AND SF SUBAXILLAR TO SF TRICEPS AND SF CALF) OF BOYS AND GIRLS BY AGE

Age class (years)	ČR				SR			
	Boys		Girls		Boys		Girls	
	X	SD	X	SD	X	SD	X	SD
1½–2	62.03	17.05	66.53	16.07	59.30	14.94	65.45	21.27
2–3	57.87	14.87	63.32	16.84	57.05	13.85	63.74	17.17
3–4	54.56	13.95	61.14	16.91	56.24	14.75	61.52	13.43
4–5	52.69	13.71	60.88	17.51	54.65	14.84	58.79	21.10
5–6	56.37	13.95	60.08	18.17	54.89	15.01	62.99	19.69
6–7	55.29	14.98	60.21	19.45	58.71	18.43	62.08	20.79
7–8	59.42	17.18	64.59	22.31	62.30	26.46	64.19	23.08
8–9	64.30	19.64	71.43	27.00	62.31	21.12	67.08	22.16
9–10	65.64	21.69	74.95	26.48	67.68	20.76	68.39	24.48
10–11	69.74	25.33	78.21	27.41	67.83	25.30	74.60	26.95
11–12	74.52	27.39	82.94	23.73	67.21	24.21	77.12	26.92
12–13	88.44	21.43	81.93	23.99	70.43	24.94	84.76	26.25
13–14	82.57	29.03	84.80	24.29	80.27	27.22	87.50	24.37
14–15	88.23	29.13	87.79	25.95	89.07	28.50	88.94	23.47

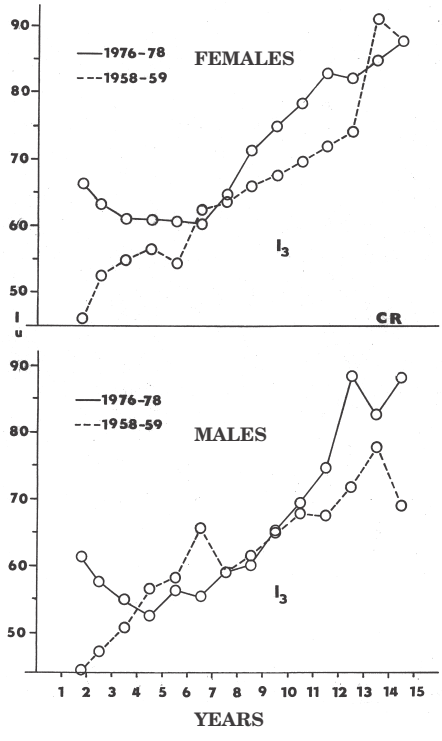

Fig. 6. Comparison of age changes of centralization index I_3 in the fifties and seventies in Czech children.

I_1 t_{548}=3.550, p<0.0005. Similar differences appear also later on.

The comparison and the analysis of data indicate that index I_2 gives most valuable results as compared to other indices. This may be due to a higher number of skinfolds assessed. Index I_1 is less characteristic for the estimation of the relative distribution of the subcutaneous fat on the trunk and extremities; however, it is useful for the evaluation of fat distribution under the conditions of e.g. the general practitioner, or in field studies and the like.

Secular age changes in fat distribution after 20 years

The comparison of our data in Czech children with similar previous results of Pařízková from the late fifties indicates a certain secular trend with regard to the amount and distribution of fat. The results are shown in Figures 4–6. The values of centrality indices were mostly higher in the fifties, especially in girls. The indices of fat distribution also changed.

Comparison of the values of $I_{1,2}$ indicates that in children measured in the seventies a relatively greater amount of subcutaneous fat was deposited on the extremities, neck and cheek. There is a difference between groups of children measured in 1957–9 and 1976–8, and according to greater values of index I_2 the difference is more marked in girls than in boys; this was more apparent after 10 years of age.

As mentioned before, I_2 appears to give a better characteristic of fat distribution, and also indicates a relative decrease of fat on the trunk in children measured in the more recent study than 20 years ago. The developmental trend of the changes concerning I_3 in older children is in contrast with the trends of $I_{1,2}$ (Figures 4–6). In fact, the centrality index I_3 shows the ratio of the subcutaneous fat on the lateral periphery of the chest (in the anterior axillary's line) and on the back (subscapular) related to subcutaneous fat on dorsal region on both extremities. We can find opposite developmental curves of centrality index I_3 compared with indices I_1 and I_2. This seems to indicate that the subcutaneous fat increased relatively more during the examined period, namely on the lower part of the trunk, especially the abdomen.

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RAZVOJ INDEKSA SREDIŠNJE RASPODJELE POTKOŽNOG MASNOG TKIVA TIJEKOM RASTA

SAŽETAK

Promjene u raspodjeli tjelesne masti praćene su u češće i slovačke djece dobi od 1,5 do 15 godina, korištenjem indeksa središnje raspodjele masnog tkiva, koji povezuju vrijednosti kožnih nabora na trupa s kožnim naborima udova, glave i vrata. Do pete godine života, potkožna mast deponirana je relativno više na udovima, glavi i vratu nego na trupu, što je izraženo nižim vrijednostima indeksa središnje raspodjele masnog tkiva. Nakon pete godine života akumulacija potkožne masti veća je na trupu, što se očituje višim vrijednostima indeksa središnje raspodjele masnog tkiva. Usporedba pojedinih indeksa pokazala je u oba spola relativno višu vrijednost potkožne masti na trupu, kod dječaka je to bilo izraženo do 12. godine života. Tijekom puberteta potkožna

mast tricepsa i podlaktice smanjena je. U djevojčica potkožna mast relativno je bila veća nego u dječaka i to na različitim pozicijama na trupu, uz iznimku dobne skupine od 14–15. godina. Depozicija potkožne masti veća je na trupu nego na glavi (obrazi) i na udovima u češće djece u usporedbi sa slovačkom, uz iznimku 12. godišnjih djevojčica. Tijekom razdoblja 1950-tih, 1960.-tih i 1970.-tih u češke djece, posebice djevojčica, taloženje potkožne masti na trupu bilo je relativno manje nego na drugim dijelovima površine tijela, što je izraženo manjim vrijednostima indeksa središnje raspodjele masti. Indeks I_2, stoga je smatran kao najvrednijim pokazateljem središnje raspodjele masnog tkiva na površini tijela.