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Ethnic Differences in Body Proportions. Genes or Environment?

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INTRODUCTION

In various ethnic groups, different parts of the body grow at different rates. As a result, adult subjects of these ethnic groups have distinctive body proportions. The question arises as to whether this is a genetic or environmental (due mainly to nutrition) effect, or results from physical activity (Wolanski, 1979). This is important for several reasons: Child growth, which manifests biological and health status is understood as a reflection of family living conditions. Additionally, growth of children is a very sensitive index of an external environment which monitors not only family conditions but also reflects the actual social, economic and cultural situation of the society (Czekanowski, 1947; Wolanski and Miesowicz, 1963; Wolanski, 1966; Eveleth and Tanner, 1976; Tanner, 1986; Bogin, 1988). The idea also exists that ethnic groups represent varying genetic potentials, as expressed by differences in several morphological traits, including body height and proportions (Bogin, 1993).

Study of human body shape is central to an understanding of several aspects of human biology and behavior. The size and shape of the human body, and body parts such as the head, trunk, legs and arms, determine the functional capabilities of our species. As a species, for example, the unique human ability to walk bipedally is, in part, a consequence of having legs longer in absolute terms than arms and which are relatively long in proportion to the length of head and trunk. For individuals, variation in body proportions influences physical performance capabilities.

The most obvious examples are seen in professional athletes where jumping performance is enhanced by relatively long legs and arms, whereas gymnastic performance is enhanced by a more "compact" body shape with relatively short leg length when compared to trunk length (Carter, 1984).

Performance of manual laborers is also influenced by body shape. Taller, longer-legged agricultural workers, such as sugar cane cutters, harvest more crops and earn more money than their smaller, shorter-legged coworkers (Spurr, 1983). Thus, body shape is both a consequence and a determinant of socioeconomic variation between human populations. It is probable, that different body proportions are due to quantity and quality of nutrition available during various growth periods.

Changes in body proportions were also studied in relation to endocrinological disturbances (Lasota et al., 1966a), physical activity and living conditions in both towns and villages (Wolanski, 1966) using a modified Decourt-Doumic method for evaluation of body proportions (Wolanski, 1962). Measurements of body proportions such as length of lower extremity relative to height, and a ratio of hip to shoulder breadths are most sensitive to both, endocrine and environmental disturbances (Lasota et al., 1966; Wolanski, 1966).

In this paper differences between Yucatecan (Mexican) and Polish urban and rural populations are presented, including a shift in dynamics of extremities growth in the Polish city population over 20 years. If such changes in dynamic of extremities growth exist, they will probably be related to living conditions.

MATERIALS AND METHODS

Body proportions were examined in 1208 subjects, mostly Maya Indians or Maya mixtures, 2-70 years of age from the towns of Merida and Progreso in Yucatan, Mexico (Tables 1-3, Wolanski, 1994). Results were compared with data for Polish populations studied in northeast Polish villages and in city of Warsaw in 1959 and 1979 (Wolanski, 1962b, 1973; Wolanski and Koziol, 1987).

When a comparison of body proportions is made for different populations, use of identical methods of measurements is very important. For both populations, in Yucatan and Poland, the

Table 1: Stature and trunk length in inhabitants of Yucatan, Mexico

Age	*Body height (B-v)*						*Trunk length (sst-sy)*					
in	*Male*			*Female*			*Male*			*Female*		
Years	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*
2	86.34	4.2	7	84.10	3.8	6	28.85	3.8	6	26.08	1.6	6
3	95.76	4.0	9	89.84	5.3	14	30.29	1.6	9	28.69	2.4	14
4	98.29	5.5	14	98.54	4.2	15	31.21	1.6	14	31.33	2.7	15
5	104.61	8.4	9	104.57	6.9	21	33.56	4.2	9	32.19	2.0	21
6	109.60	4.2	14	112.91	5.7	16	34.26	2.2	14	34.48	2.8	16
7	117.53	6.2	16	114.39	6.4	15	36.85	1.7	16	34.54	3.5	15
8	117.87	7.0	13	120.74	7.5	24	36.76	2.2	13	36.75	3.8	24
9	123.48	6.4	13	126.04	4.5	17	38.38	3.9	13	37.73	2.6	17
10	128.75	5.9	11	129.70	11.5	15	38.45	1.5	11	39.12	4.1	15
11	135.83	8.6	15	136.58	6.8	12	42.24	2.3	15	41.80	4.1	12
12	141.75	6.7	27	145.62	8.0	17	42.97	6.1	27	42.19	6.5	17
13	149.39	9.4	27	147.82	7.5	15	45.24	4.1	27	44.10	3.2	15
14	151.95	6.4	22	149.62	8.1	18	47.41	7.6	22	46.96	4.0	18
15	157.71	6.0	22	149.52	5.3	16	48.61	2.7	21	46.16	2.4	16
17	161.76	8.1	55	150.18	5.4	56	50.21	3.4	55	46.49	2.7	56
22	162.66	7.1	47	149.76	6.6	43	50.65	3.2	37	48.45	4.7	24
27	164.10	7.1	32	149.35	6.6	48	49.70	1.3	3	47.06	3.9	10
35	160.29	5.6	113	148.23	5.4	122	51.70		1			
45	159.06	6.0	91	148.03	5.4	88						
55	158.45	6.5	37	145.49	4.9	19						
65+	159.82	6.9	11	147.25	5.2	4						

Table 2: Upper and lower extremity lenght in inhabitants of Yucatan, Mexico

Age	*Upper extremity length (a-da)*						*Lower extremity length (B-sy)*					
in	*Males*			*Females*			*Males*			*Females*		
Years	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*
2	38.11	1.9	7	36.38	1.9	6	38.52	3.5	6	38.75	2.0	6
3	41.82	2.2	9	39.68	2.7	14	44.50	2.1	9	41.12	3.3	14
4	44.19	3.0	14	44.31	1.9	15	45.34	4.3	14	45.86	2.3	15
5	47.23	4.3	9	46.55	3.1	21	48.60	3.7	9	49.20	3.4	21
6	50.02	2.7	14	50.79	3.2	16	52.57	3.1	14	55.43	4.1	16
7	54.19	3.3	16	51.46	2.9	15	56.66	4.3	16	56.98	3.6	15
8	53.05	4.9	13	54.09	4.0	24	57.80	4.4	13	60.63	5.8	24
9	55.78	3.9	13	57.64	2.6	17	60.87	4.9	13	54.05	3.0	17
10	58.79	3.7	11	58.81	5.7	15	66.01	4.8	11	65.68	7.6	15
11	62.33	4.0	15	61.85	2.4	12	68.41	6.4	15	69.58	4.0	12
12	64.47	3.2	27	64.86	5.0	17	72.13	5.0	27	76.34	5.9	17
13	68.49	5.4	27	66.68	3.9	15	77.26	5.5	27	77.20	6.1	15
14	69.56	3.0	22	67.52	3.6	18	77.00	6.1	22	75.34	4.3	18
15	72.92	3.7	22	66.83	2.3	16	80.81	3.9	21	76.50	3.9	16
17	74.76	4.2	55	67.39	3.0	56	82.82	6.0	55	76.70	3.9	56
22	75.52	3.7	37	68.52	3.1	24	84.18	4.8	37	76.67	4.4	24
27	75.87	1.9	3	66.33	5.0	10	86.17	1.3	3	75.11	5.8	10
35	76.00		1	-	-		85.50		1			

same methods and instruments were used (Martin and Saller, 1957).

Because body segments are in some proportion to body size, to evaluate differences between subjects of different stature, the percentile indices (relative values) for some body measures related to stature as well as other proportions were calculated. Indices included: lengths of upper and lower extremities related to height (UEI, LEI), ratios between both extremities (IEI), trunk length relative to height (TLI), shoulder and hip breadth relative to height (SBI,

Table 3: Shoulder and hip breadth in inhabitants of Yucatan, Mexico

Age	*Shoulder breadth (a-a)*						*Hip breadth (ic-ic)*					
in	*Males*			*Females*			*Males*			*Females*		
Years	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*
2	195.43	12.1	7	191.83	9.5	6	148.00	8.5	7	148.17	7.5	6
3	217.44	10.7	9	204.43	11.9	14	165.00	11.4	9	150.36	14.6	14
4	222.14	13.4	14	219.87	12.4	15	164.14	10.2	14	168.20	12.4	15
5	231.22	23.5	9	230.90	14.7	21	176.22	15.0	9	172.95	12.5	21
6	246.29	14.7	14	248.69	16.0	16	181.64	8.0	14	188.31	15.3	16
7	261.25	15.7	16	248.47	12.3	15	194.19	13.5	16	188.27	13.3	15
8	262.92	15.3	13	264.88	18.3	24	191.15	13.6	13	201.67	14.1	24
9	275.31	15.3	13	278.41	18.2	17	199.08	18.0	13	213.35	22.0	17
10	277.18	19.0	11	280.40	25.8	15	208.18	11.4	11	213.47	24.1	15
11	294.87	19.8	15	296.50	18.5	12	221.13	21.5	15	227.83	18.4	12
12	314.85	18.6	27	321.00	22.2	17	237.78	20.9	27	243.76	22.3	17
13	331.37	19.8	27	318.40	22.4	15	245.52	20.1	27	246.73	27.1	15
14	339.41	21.5	22	323.06	15.7	18	249.32	13.4	22	259.17	17.5	18
15	353.41	20.3	22	329.50	20.1	16	260.00	26.3	22	265.50	22.9	16
17	363.80	21.1	55	336.55	15.7	56	271.40	18.3	55	267.18	23.9	56
22	376.13	20.6	47	332.11	18.2	44	270.94	21.0	47	272.89	21.7	44
27	382.94	19.0	32	338.13	16.8	48	273.19	16.9	32	284.04	25.2	48
35	376.18	20.1	113	339.55	17.9	122	283.50	25.6	113	292.05	25.8	122
45	376.30	18.9	91	344.49	18.1	88	285.30	26.7	91	300.99	23.4	88
55	372.62	15.9	37	341.42	13.9	19	289.19	24.4	37	304.16	17.9	19
65+	370.64	18.7	11	345.75	12.8	4	285.36	21.2	11	308.50	22.0	4

HBI) and a ratio between shoulder and hip breadths (SHI).

RESULTS

During the pre-pubertal period, upper extremities (UEI) were relatively longer in Yucatecans than in Poles (Fig. 1). At this age in both populations, lower extremity lengths (LEI) were relatively similar but started to decrease in Yucatecans just after puberty (Fig. 2), when trunk length increased. However, Yucatecan trunk lengths (TLI) were relatively greater for all age groups (Fig. 3). Yucatecans showed a greater ratio of upper to lower extremity lengths (interextremity index, IEI) than Poles (Fig. 4). This was observed during the childhood and pubertal period, particularly among boys.

Shoulder breadths (SBI) were relatively the same for both populations at a younger age (Fig. 5). After puberty, relatively wider shoulder breadths were observed for males than for females.

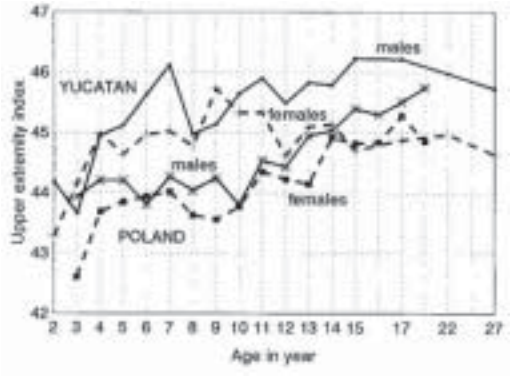

Fig. 1. Age changes of upper extremity index (a-da:B-v*100) in inhabitants of urban areas in Yucatan and Poland

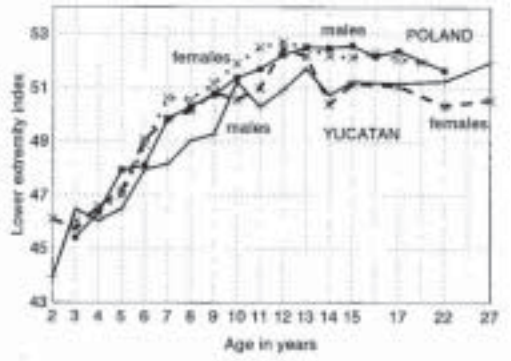

Fig. 2. Age changes of lower extremity index (B-sy:B-v*100) in inhabitants of urban areas in Yucatan and Poland

Fig. 3. Age changes of trunk length index (sst-sy:B-v*100) in inhabitants of urban areas in Yucatan and Poland

Fig. 4. Age changes of inter-extremity index (a-da:B-sy*100) in inhabitants of urban areas in Yucatan and Poland

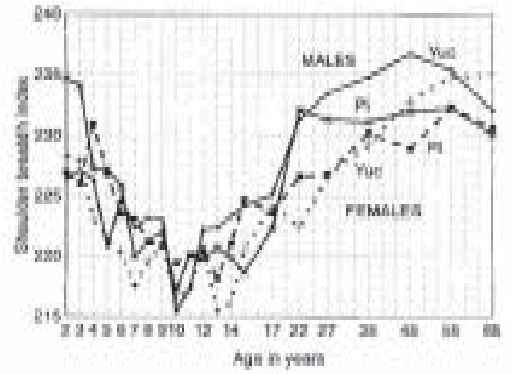

Fig. 5. Age changes of shoulder breadth index (a-a:B-v*100) in inhabitants of urban areas in Yucatan and Poland

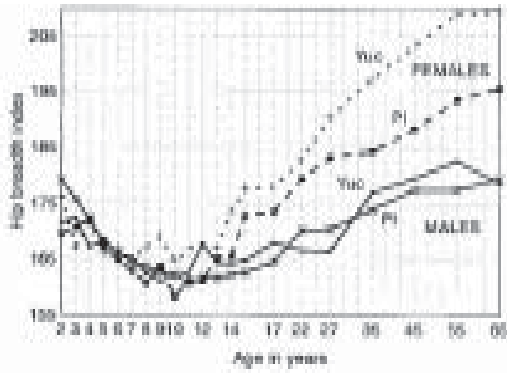

Fig. 6. Age changes of hip breadth index (ic-ic:B-v*100) in inhabitants of urban areas in Yucatan and Poland

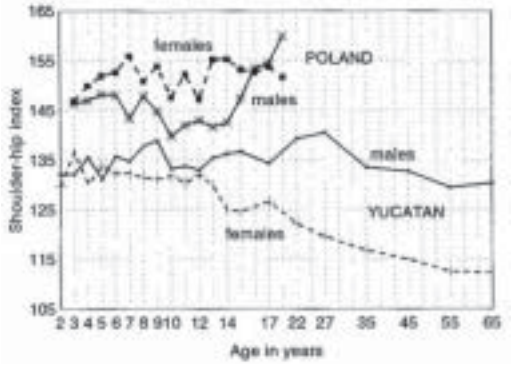

Fig. 7. Age changes of shoulder-hip index (a-a:ic-ic*100) in inhabitants of urban areas in Yucatan and Poland

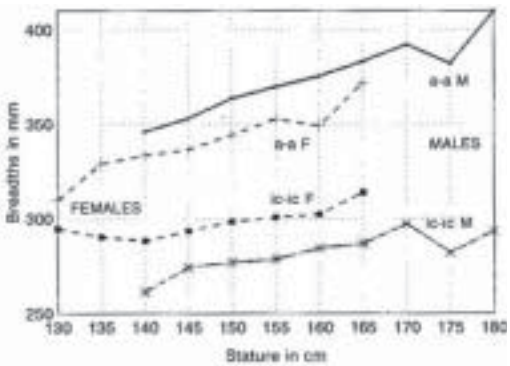

Fig. 8. Changes of shoulder (a-a) and hip (ic-ic) breadths with increasing stature in adults 18-75 years old from Yucatan

Hips (HBI) did not exhibit differences in childhood between the two compared populations nor between the sexes, but after puberty such differences increased between the sexes and among the females of both populations (Fig. 6). However, the shoulder-hip ratio (SHI) was much smaller (wider hips) for Yucatecans (Fig. 7). In Poles tall adolescence girls have greater shoulders-hips

ratio than boys and only after the age of 15-17 years males have relatively wider shoulders than females (greater ratio). The greater shoulder-hip ratio in males than females is typical for almost all age groups in Yucatecans.

It is interesting that for the Yucatecan sample shoulder and hip breadths increase in adults with increasing stature (age independent values). This is more clearly seen among males than females (Fig. 8). In females with stature 130-140 cm., hip breadth actually decreases with increasing stature. However, changes in shoulder and hip breadths between age groups, simulating secular changes, show changes not adequate to observed for increasing stature. Shoulder breadth shows a very small increase in males and a decrease in females (Fig. 9), whereas hip breadth decreases in both sexes with increasing age of groups.

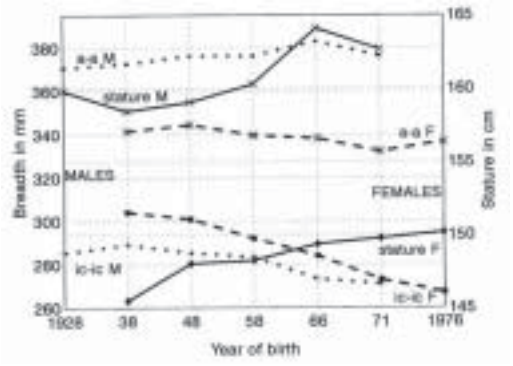

Fig. 9. Secular changes in shoulder (a-a), and hip (ic-ic) breadths, and in stature in populations of Yucatan (Mexico) are not parallel

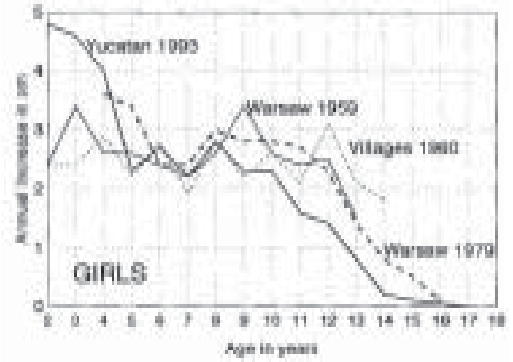

Fig. 10b Annual increase in upper extremity length (a-da) in boys (a) and girls (b) from Polish villages and city (Warsaw, studied twice in 1959 and 1979) and from Yucatan.

DISCUSSION

Measurements showed that Yucatecans have relatively longer upper extremities and trunks, whereas Poles have longer lower extremities. Data for relative shoulder breadth in both sexes and hip breadth in males were rather similar in both countries. However, Yucatecan females have relatively broader hips. When comparing shoulder to hip breadths (SHI), Yucatecans have much wider hips and a little narrower shoulder than Poles. In our endocrinological studies we found that lower extremities and especially hips are very sensitive to any growth disturbances (Lasota et al., 1966).

It has been suggested that differences in BMI are mostly related to body proportions (length of legs). The values of BMI were very great for

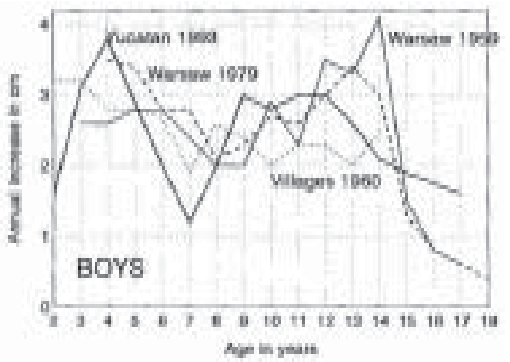

Fig. 10a. Annual increase in upper extremity length (a-da) in boys (a) and girls (b) from Polish villages and city (Warsaw, studied twice in 1959 and 1979) and from Yucatan.

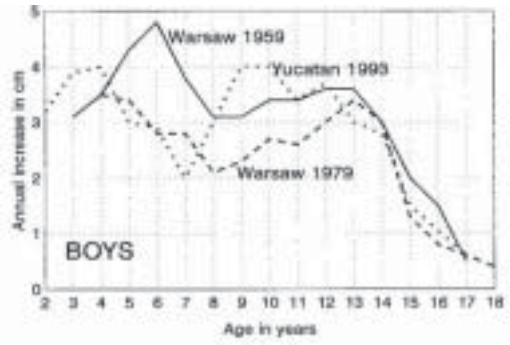

Fig. 11a. Annual increase in lower extremity length (B-sy) in boys (a) and girls (b) from Polish city Warsaw (studied twice in 1959 and 1979) and from Yucatan.

Fig. 11a. Annual increase in lower extremity length (B-sy) in boys (a) and girls (b) from Polish city Warsaw (studied twice in 1959 and 1979) and from Yucatan.

Yucatecans and small for Poles. A decrease with age of relative trunk length (TLI) and a subsequent increase of weight for height (BMI) were observed especially in boys. An exception was seen among both sexes during puberty when an increase, followed by one-year decrease and again increase in relative trunk length was observed. Probably this phenomenon is related to pubertal growth spurt in growth of lower extremities.

In Yucatecan populations secular increase of stature is accompanied by small increase of shoulder breadth among males, but by a decrease in shoulder breadth among females and in hip breadths among both sexes. These changes indicate a trend towards a more slender trunk.

An annual increase in length of upper and lower extremities were calculated in Yucatan (Mexican) populations and in Polish rural and urban populations. There are differences in rate of growth of extremities between Yucatan and Polish populations, but also between Polish rural and urban populations, especially in early childhood (first 5 years of life) and in pubertal period (Figs. 10a,b and 11 a,b). Differences between Yucatecan and Polish populations can be related to differences in gene pools. Such differences among rural and urban Polish populations are probably mostly related to living conditions. However, were analyzed also changes is growth rate in the same urban (Warsaw city) population in 1959 and 1979. Warsaw in this period shows very small migrations, because lack of apartments and restriction to be permanent resident of this city. So, probably in 1959 and 1979 the Warsaw population had a similar gene pool. But living conditions over this period change tremendously. Especially in 1970-1976 great positive economic and social changes were noticed. Probably these changes influenced growth rate of children, especially length of extremities in sensitive developmental periods. The example observed in Poland and this related to secular changes in Yucatan, suggest that differences in body proportions (especially trunk breadths and extremities length) between various populations (also ethnic groups) are mainly related to environmental factors.

CONCLUSIONS

1. The differences in proportions of upper and lower extremities to stature, and smaller, only since puberty, in shoulders and hips breadths to stature were found among Polish and Yucatecan populations, representing the contrast ethnic groups:
   a) Upper extremities are relatively longer in Yucatecans in pre-pubertal period. Lower extremities are similar at this age in both populations and start to be relatively longer in Poles after puberty. Interextremity index shows that upper extremities in relation to lower ones are relatively longer in Yucatecans than in Poles.
   b) Trunk is relatively longer in Yucatecans in each age group.
   c) Breadth of shoulders and hips for height do not show great differences between both populations in childhood, but increase during puberty. However, shoulder-hip ratio is much lower (wider hips) in Yucatecans.
2. Dynamics of growth of extremities, particularly in the first five years of live, and than in the pubertal period is different in various populations, and it was also seen in the same Warsaw population through 20 year period.
3. The results of these studies suggest that differences in extremities length depend rather on environmental conditions, which influence growth rate especially in early childhood and pubertal periods.

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KEY WORDS Body Segments. BMI. Yucatan. Mexico. Poland.

ABSTRACT In various ethnic groups adult subjects have contrasting body proportions. Are there effects of differences in genes and/or in living conditions? The problem was examined in 1208 subjects, aged 2-70 years from Merida and Progreso in Yucatan, Mexico. Results were compared with published own data for Polish populations. Because body segments are in some proportion to body size, to investigate this problem, the percentile indices were calculated. For analysis were used: lengths of upper and lower extremities for height (UEI, LEI), ration between both extremities (IEI), trunk length for height (TLI), shoulder and hip breadth for height (SBI, HBI) and ratio between both breadths (SHI). Upper extremities (UEI) are relatively longer in Yucatecans in the pre-pubertal period, whereas lower extremities (LEI) are similar at this age in both populations and start to be relatively shorter in Yucatecans only just after puberty. However, trunk (TLI) is relatively longer in all ages. Interextremity index (IEI) shows greater ratio of upper to lower extremity lengths in Yucatecans than in Poles. Shoulders (SBI) do not show differences between both populations, and after puberty there are observed relatively wider shoulders in males than in females. Hips (HBI) do not exhibit differences in childhood between two compared populations and sexes, but since puberty such differences increase between sexes and in females of both populations. However, shoulder-hip ratio (SHI) is much lower (wider hips) in Yucatecans. Dynamics of growth of extremities particularly in first five years of live and than in pubertal period is different in various populations. Shift in periods of intensive extremities growth in Warsaw children over 20 years is also observed. These last results and secular changes in the Yucatan population suggest that differences in extremities length depend rather from environmental conditions, which influence on growth rate especially in early childhood and pubertal periods.

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