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PHYSIQUE OF YOUNG FEMALE GYMNASTS

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Abstract: The authors studied 132 young female gymnasts in Hungary. The age of these girls varied between 9 and 19 years. Based on a detailed anthropometric survey the authors analysed the physical development status (body measurements) and sexual maturity (age at menarche: „status quo" method; probit analysis) as well as the skeletal age (TW2 method) of the subjects.

The data of body measurements compared with the very recent Hungarian National Growth Standards show that the young female gymnasts are smaller by 3–10 cm and lighter by 3–9 kg than their „normal" counterparts. Other body measurements – except subcutan fat – show the same trend. Their somatotype was 2.54–4.05–3.39. The age at menarche was m=15.04 ± 0.62 year, which is later by 2–2.5 years than the recent Hungarian medians (12.6–13.0 y). The skeletal age of the girls was found to be behind their chronological age, i.e. their skeletal maturity delayed.

The retardation in growth and development process of young female gymnasts could be explained by the enormous heavy training and a cruel diet, but also a selection for the sport event can play a special role.

Key words: Physique, Somatotype, Body measurements, Menarche, Skeletal age, Female gymnasts.

Introduction

The relationship between physiques and sport achievements is the centre of interest of physical training and sport sciences. Philostratos Flavius (3rd century B. C.) stated what is the most suitable physique of a contestant in the different olympic games and encouraged the right physical education in his „Gymnastikos". In his study, which is already a standard work, Godin (1901) demonstrated that apparatus work has an advantageous effect on the width development of the trunk and on the muscle development of the extremities. Since the 1928 Olympic Games investigations on physique of athletes were carried out at almost every Olympic Game and also at several World Competitions. Unfortunately most of these examinations referred only to men. Since the 1960s perfectly reliable data on female athletes's physique, moreover of female gymnasts, have been available and comes from investigations of scientific value. From among the latter we mention the following investigations:

In 1968 De Garay – Levine – Carter (1974) investigated 115 female gymnasts at the Mexico Olympic Games. Their mean somatotype was 2.7–4.2–2.8; 62% of them was found to be in the central field and 29% in the mesomorphic fields.

Hirata (1979) based mostly on his own investigations carried out on female gymnasts at the Tokyo Olympic Games, stated that the female gymnasts were the youngest, the shortest and the most linear among the female athletes.

Carter et al. (1982), among others, investigated 15 female gymnasts at the Montreal Olympic Games. The mean of their somatotypes was: 2.1–4.0–3.4

Although gymnastics has a long history in Hungary, there were no scientific reports on physique characteristics of elite Hungarian female gymnasts. The Hungarian Gymnastics Federation in its concern for the optimal growth and development of participants in the sport expressed a need for a scientific appraisement to determine: (1) the somatic and physique characteristics of elite young Hungarian female gymnasts and (2) make preliminary assessment of the possible effects of intensive training on the normal pattern of growth and development.

Material and Methods

The investigation was carried out in January, 1983 and involved 132 young female gymnasts, all Hungarian, Caucasian between the ages 8.5 and 21.0 years. The majority of them had been actively engaged in the sport for 5 years and all were rated in the elite class. Although all of the data were useful in appraising individual characteristics, the numbers in the total sample were insufficient for groups analysis other than for those between the ages 11 and 14 years old (N=91).

The measurement protocol contained data of birth, height, weight and 15 other anthropometric items consistent with the technique of Martin (Martin and Saller 1957) in accord with the general plan proposed for the International Biological Programme (Tanner et al. 1969). Somatotype photographs in accord with the technique described by Carter (1975) and hand and wrist X-rays as specified by Tanner et al. (1975) were obtained in all the subjects.

Concurrently, data on whether the subjects had experienced menarche and auxillary data from gynaecological and psychological examinations were obtained.

The anthropometric data were summarized by conventional descriptive statistics, somatotypes calculated by Heath–Carter method (Carter 1975) with sample homogeneity described by somatotype dispersion distances as described by Ross and Wilson (1973). The estimation of age at menarche was made from the „status quo" data by probit analysis (Weber 1957). Radiographs were rated by one of the authors, by an experienced investigator (G. G.) who had established reliability with original ratings of the Tanner-Laboratory (made by R. H. Whitehouse) in the Department of Anthropogenetics, Vrije Universiteit Brussel, Brussels.

The above data were compared to individual age-matched samples of girls from the Hungarian National Growth Study (Eiben–Pantó 1981, 1986, Pantó–Eiben 1984).

Results and Discussion

Body measurements

The body measurements of the female gymnasts compared to the Hungarian national reference values (Eiben–Pantó 1986) are presented in Table 1. The gymnasts were significantly shorter than the girls in the reference group ranging from 3.5–9.8 cm less than Hungarian girls. They were also shorter in sitting height, and upper and lower extremity length. One possible explanation of the short stature is that the gymnasts came from families with short parents. This was not the case in this study since the fathers' height of 172.7 (SD 6.0) cm and mothers' height of 160.1 (SD 6.0) cm were not appreciatively different from the Hungarian population 172.0 cm and 162.0 cm for adult males and females.

Compared to the Hungarian national height standards (Eiben–Pantó 1986) the mean height values of the female gymnasts were below the 25th percentile, except the 10 year-old ones, however, even the 11–14 year-old female gymnasts investigated intensively were at the 10th percentile (Fig. 1).

The female gymnasts were significantly lighter 3.3–9.4 kg than the respective Hungarian girls. Compared to the Hungarian national weight standards (Eiben–Pantó 1986) the mean weight values of the female gymnasts were below the 50th percentile, however, the 11–14 age groups of them were between the 10th and 25th percentiles (Fig. 2).

The weight-for-height data of the female gymnasts compared to the Hungarian national reference values were more reassuring than their height and weight data in this comparison.

Table 1. Body measurements of the 10–15 year-old females gymnasts compared to the Hungarian national reference values

Age (year)	Female gymnasts N	$\bar{x}$	SD	W	Hungarian national reference values N	$\bar{x}$	SD	W
				Height (cm)				
10	9	134.8	5.5	124.7–141.3	1286	138.29	6.65	113.8–166.3
11	26	136.3	5.3	124.8–148.5	1355	144.68	7.18	120.0–168.0
12	18	140.9	6.3	127.3–156.8	1374	150.66	7.57	127.0–174.2
13	18	147.4	6.2	133.4–156.8	1373	156.03	6.89	126.5–181.0
14	29	150.9	6.5	135.7–164.0	1325	159.31	6.43	134.5–180.3
15	11	156.8	4.4	145.1–162.9	1563	161.16	6.34	137.4–191.9
				Weight (kg)				
10		28.3	1.7	25.2–30.5		31.616	6.85	20.0–63.0
11		29.9	4.3	22.4–39.7		36.062	8.03	20.0–78.0
12		32.3	3.8	25.6–41.3		40.860	9.21	20.0–89.5
13		37.2	4.3	27.5–42.9		46.615	9.61	21.0–93.0
14		42.2	5.8	30.3–55.2		49.830	9.06	27.5–94.0
15		47.7	6.0	33.7–55.5		53.000	8.80	26.5–98.0
				Sitting height (cm)				
10		70.7	2.3	65.8–74.4		73.026	3.48	57.5–88.0
11		71.4	2.9	63.4–78.0		75.804	3.75	62.8–87.8
12		73.5	3.3	67.3–81.2		78.885	4.16	59.9–91.0
13		76.2	3.6	69.7–81.2		81.860	3.94	64.2–92.6
14		79.1	3.7	70.1–87.7		83.990	3.64	66.3–96.6
15		81.7	3.2	73.9–85.6		85.327	3.46	61.7–96.6
				Length of the upper extremity (cm)				
10		58.1	2.6	54.4–62.4		58.84	3.69	43.4–84.8
11		59.1	2.4	54.9–63.6		61.85	3.85	44.8–75.4
12		60.6	3.4	54.0–65.7		64.70	4.14	42.3–80.2
13		65.3	3.5	57.1–71.9		67.27	3.92	47.8–83.8
14		66.1	3.9	57.8–74.0		68.65	3.70	51.9–82.3
15		69.1	2.4	65.1–73.7		69.34	3.75	44.5–83.8
				Length of the lower extremity (Height of the anterior superior iliac spine, cm)				
10		76.4	3.7	70.8–81.2		77.21	4.57	54.8– 92.0
11		78.1	3.3	71.6–85.4		81.39	4.96	57.4– 96.2
12		80.2	4.1	71.2–89.4		85.05	4.92	70.4– 99.8
13		84.2	3.8	75.3–90.6		87.91	4.61	63.1–102.5
14		85.5	3.8	78.7–92.9		89.37	4.55	64.0–105.6
15		88.7	3.1	82.7–93.3		89.99	4.58	69.3–106.6

Table 1 cont.

Age (year)	Female gymnasts $\bar{x}$	SD	W	Hungarian national reference values $\bar{x}$	SD	W
			Biacromial diameter (cm)			
10	29.8	1.2	28.1–31.7	30.24	1.88	23.5– 39.6
11	30.1	1.5	27.4–33.2	31.57	1.99	24.0– 39.0
12	31.2	1.6	27.3–33.6	32.92	2.11	25.7– 40.4
13	32.8	2.0	28.7–36.0	34.26	1.90	26.1– 40.3
14	33.9	2.0	29.3–38.7	35.08	1.82	28.7– 41.5
15	35.4	1.4	32.5–37.3	35.57	1.75	29.3– 40.6
			Biilocristal diameter (cm)			
10	19.5	0.6	18.8–20.4	21.45	1.86	16.7– 30.0
11	20.0	1.0	17.9–22.1	22.58	1.98	17.9– 31.5
12	20.5	1.3	18.3–23.0	23.73	2.14	17.1– 34.0
13	22.1	1.4	20.0–24.1	25.03	1.98	17.6– 34.0
14	23.0	1.4	20.1–26.1	25.72	1.91	20.2– 33.1
15	23.4	1.1	21.3–25.1	26.34	1.92	20.7– 34.8
			Bicondylar width of humerus (cm)			
10	53.9	2.2	50–58	54.13	3.66	42– 69
11	54.8	2.8	51–62	56.57	3.61	45– 73
12	56.1	2.9	50–62	57.98	3.68	45– 73
13	58.4	2.4	54–63	59.39	3.52	49– 73
14	59.3	2.1	56–66	60.15	3.41	48– 73
15	60.9	2.9	56–65	60.71	3.46	51– 74
			Bicondylar width of femur (mm)			
10	77.6	2.4	74–82	81.77	5.43	66–105
11	79.4	3.7	73–87	84.81	5.59	65–109
12	81.6	3.4	76–89	86.74	5.65	66–110
13	82.5	3.3	76–87	88.79	5.70	67–117
14	84.5	3.2	78–92	89.83	5.52	77–116
15	86.4	3.7	77–93	91.12	5.57	72–118
			Chest circumference (cm)			
10	63.6	1.7	61.2–66.5	65.18	6.19	52.0– 93.0
11	65.7	2.7	59.8–71.2	68.85	6.61	54.5– 99.2
12	68.3	3.8	62.8–76.4	72.07	6.80	53.2–103.5
13	72.5	3.4	64.5–76.8	76.38	6.72	55.3–107.3
14	78.4	5.3	64.7–89.0	78.29	6.06	60.8–111.0
15	81.6	3.9	73.9–88.4	80.28	5.69	61.2–109.0

Table 1 cont.

Age (year)	Female gymnasts $\bar{x}$	SD	W	Hungarian national reference values $\bar{x}$	SD	W
			Upper arm circumference, relaxed (cm)			
10	19.5	1.0	17.4–21.1	19.84	2.59	13.8– 31.5
11	19.5	1.2	17.0–22.5	20.67	2.74	14.1– 32.0
12	20.3	1.5	17.7–23.2	21.52	2.77	14.6– 32.8
13	21.4	1.2	18.0–23.8	22.68	2.92	16.1– 37.2
14	22.8	1.6	19.3–26.0	23.37	2.72	16.3– 35.5
15	24.1	2.0	19.5–26.8	24.24	2.63	16.1– 35.0
			Upper arm circumference, contracted (cm)			
10	20.2	1.0	17.9–21.8	20.54	2.60	14.1– 31.7
11	20.4	1.4	17.3–23.6	21.42	2.77	15.2– 33.6
12	21.1	1.5	18.2–23.8	22.27	2.80	15.8– 34.2
13	21.9	1.3	18.2–24.6	23.45	2.93	17.0– 37.8
14	23.5	1.6	19.8–26.5	24.16	2.70	17.8– 35.7
15	24.9	2.0	20.2–27.4	24.99	2.64	17.0– 35.8
			Calf circumference (cm)			
10	27.2	0.8	25.7–28.6	28.01	2.75	16.5– 39.2
11	27.6	1.6	24.3–31.5	29.46	3.15	17.7– 43.0
12	28.7	1.5	25.8–31.0	30.81	3.23	22.3– 45.5
13	30.4	1.7	26.0–33.0	32.47	3.23	18.0– 45.1
14	31.7	2.1	26.5–34.8	33.25	3.03	22.8– 47.1
15	33.5	1.9	29.5–36.3	34.34	2.90	23.2– 46.5
			Skinfold over triceps (mm)			
10	8.1	1.7	5–10	14.27	5.33	2–38
11	7.8	1.6	5–12	14.97	5.62	2–38
12	8.3	2.7	5–14	15.39	5.61	4–47
13	8.7	2.6	5–13	16.26	5.95	5–43
14	8.7	2.2	5–14	17.27	5.66	6–38
15	10.3	2.4	7–15	18.85	5.68	4–41
			Skinfold subscapular (mm)			
10	4.8	0.8	4– 6	9.25	5.50	3–40
11	5.0	0.8	4– 7	10.17	5.80	2–40
12	5.3	1.2	3– 8	11.02	5.82	3–43
13	5.8	1.3	3– 8	12.28	6.15	4–43
14	7.3	2.8	4–18	13.14	5.85	3–47
15	8.0	2.0	5–12	14.04	5.86	4–48

Table 1 cont.

Age (year)	Female gymnasts $\bar{x}$	SD	W	Hungarian national reference values $\bar{x}$	SD	W
			Skinfold suprailiac (mm)			
10	6.9	2.8	3–11	16.39	9.49	2–52
11	7.0	1.9	3–11	18.44	9.67	3–53
12	8.7	3.9	4–17	19.38	9.47	3–57
13	9.2	3.1	3–14	21.39	9.39	5–54
14	11.7	4.3	4–25	22.61	8.90	3–55
15	12.2	4.0	7–20	23.84	8.71	6–53
			Skinfold medial calf (mm)			
10	8.6	2.3	5–13	16.14	6.10	3–46
11	8.5	1.8	6–14	17.59	6.74	3–43
12	9.2	2.6	6–14	18.44	6.85	5–56
13	10.0	3.1	4–15	19.67	7.03	6–52
14	9.0	2.6	5–17	20.75	6.76	5–53
15	10.2	2.8	6–14	21.92	6.86	3–52

The majority of the gymnasts were in the channels between the 25th and 75th percentiles, i.e. their body build is more or less shapely (Fig. 3).

The female gymnasts were also smaller than their counterparts in width measurements of the trunk, less so in the biacromial width (0.2–1.5 cm) than the bicristal width (2.0–3.2 cm) indicating a slightly more robust shoulder girdle. The female gymnasts were only slightly smaller in bicondylar humerus width (0.2–1.9 mm) whereas the differences in bicondylar femur width were larger in the range of 4.2–6.3 mm. The gymnasts were smaller than the reference national sample in girths, however, in upper arm circumference the differences were negligible and presumably if corrected for subcutaneous adiposity they would be significantly larger than the other girths perhaps reflecting muscularity in the arms. The subcutaneous adiposity values of gymnasts estimated by skinfolds were smaller than those of the reference national sample.

Somatotype

As a group the female gymnasts were primarily ectomorphic-mesomorph with Heath–Carter somatotype rating of 2.54–4.05–3.39. Figure 4 shows that female gymnasts ranged from mesomorphic-endomorph through mesomorph-endomorph, endomorphic-mesomorph, balanced mesomorph, ectomorphic-mesomorph, mesomorph-ectomorph to mesomorphic-ectomorph and balanced ectomorp as well as the central category.

The Hungarian female gymnasts' sample had mean somatotypes which were somewhere between those of the Mexico Olympic Games female gymnasts of 2.7–4.2–2.8 reported by de Garay et al. (1974) and the Montreal Olympic Games female gymnasts of 2.1–4.0–3.4 reported by Carter et al. (1982). In one of his papers Carter (1981, page 92) gave an overview on some characteristics of young female gymnasts who represented different age-groups, nations, races, physical maturity, etc. In Carter's table mean values of endomorphy, mesomorphy and ectomorphy varied between 1.4 and 3.8, than 3.3 and 5.2, than 1.6 and 4.1, respectively. The Hungarian sample is at about the middle of these ranges in endomorphy and mesomorphy, however, in ectomorphy it is above of it.

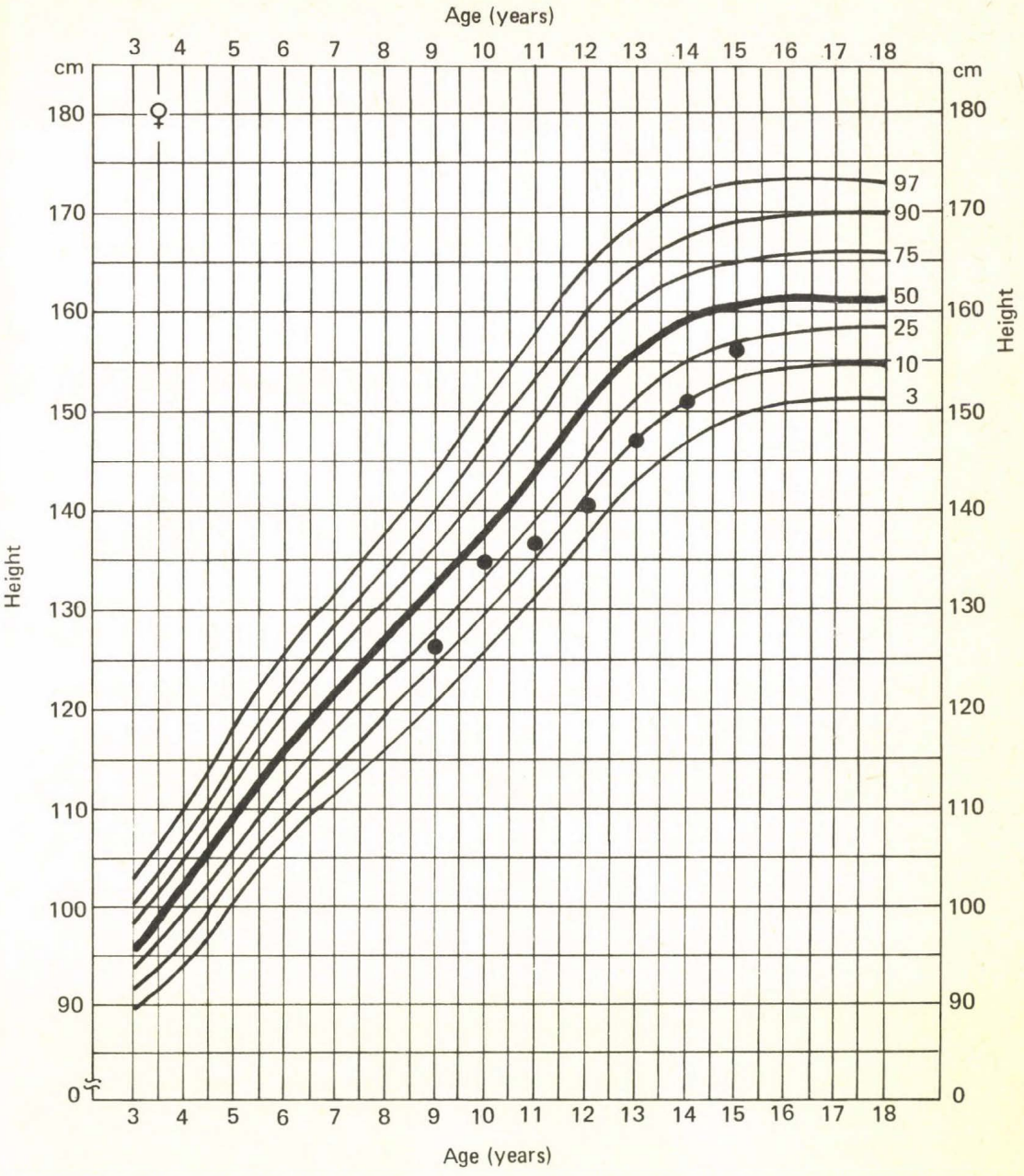

Fig. 1: Mean heights of the female gymnasts plotted on the Hungarian National Height Standards' percentile curves

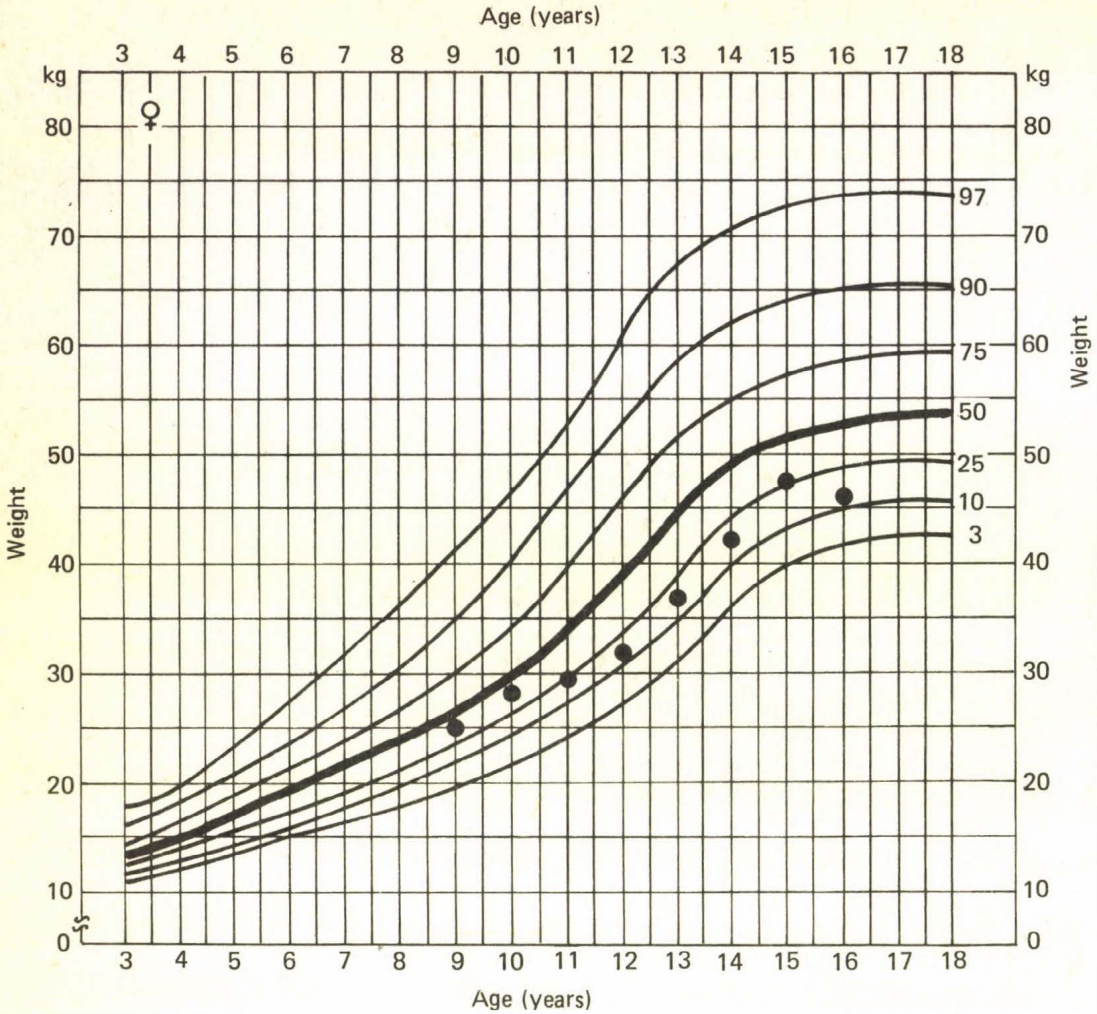

Fig. 2: Mean weights of the female gymnasts plotted on the Hungarian National Weight Standards' percentile curves

Skeletal age

In the majority of the age-groups investigated the skeletal age and the chronological age of the female gymnasts differed from each other. Before puberty, in the 9 and 10 year age-groups, there is a positive difference, except the carpal-age of the 10 year-old group in whom a delay of a quarter-of-a-year was found. By the age 11 in all age-groups and in all the three kinds of the skeletal age there is a delay, compared to the standards. The backwardness in skeletal age in the 15 and 16 year-old gymnasts is the most remarkable, e.g. in 20TW2 it is about one-and-a-half year. Based on these data it can be stated that in the skeletal maturation in female gymnasts there is a remarkable retardation, especially at puberty (Table 2., Fig. 5)

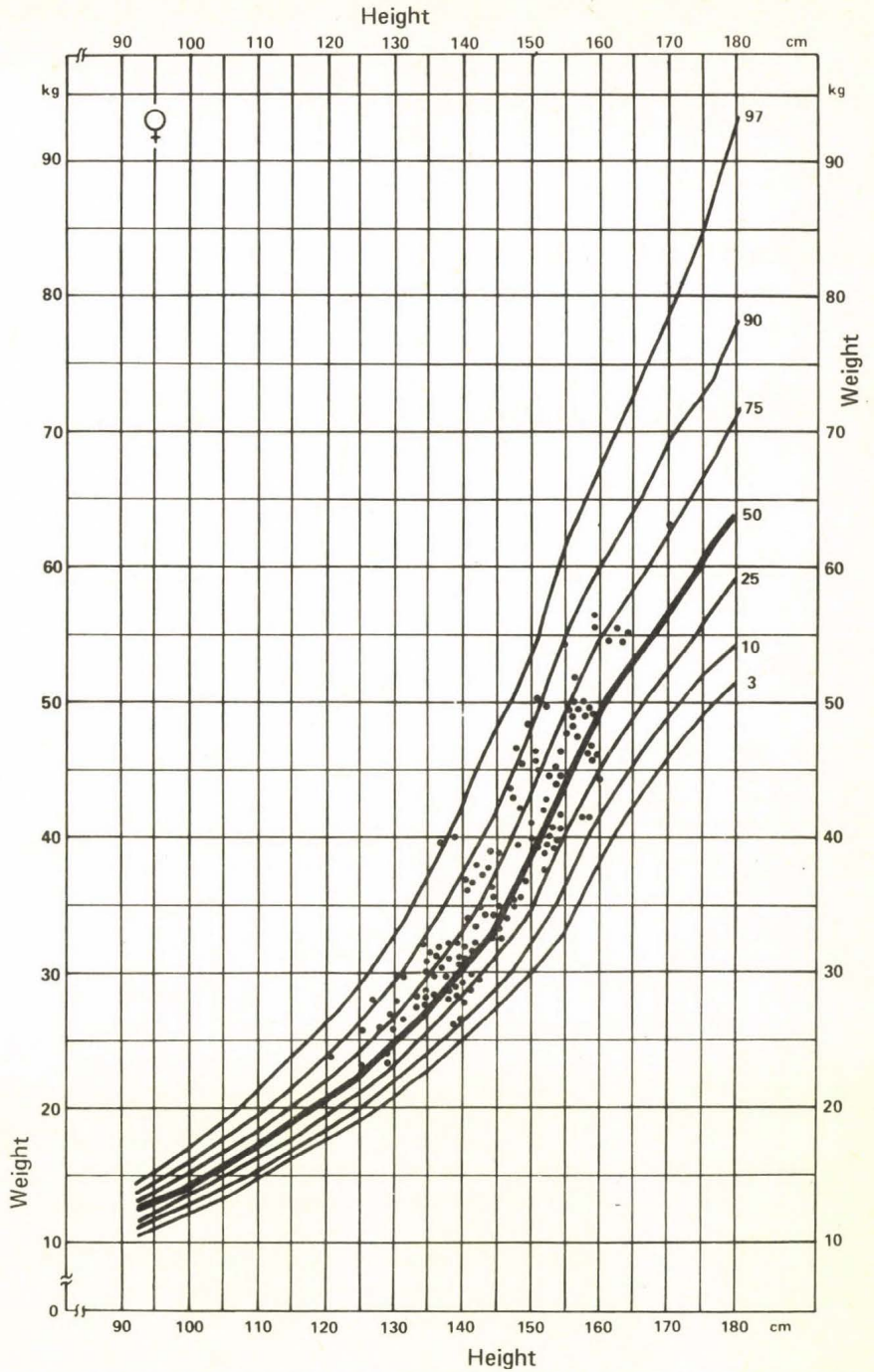

Fig. 3: Female gymnasts on the Hungarian National Growth Standards' weight-for-height percentile curves

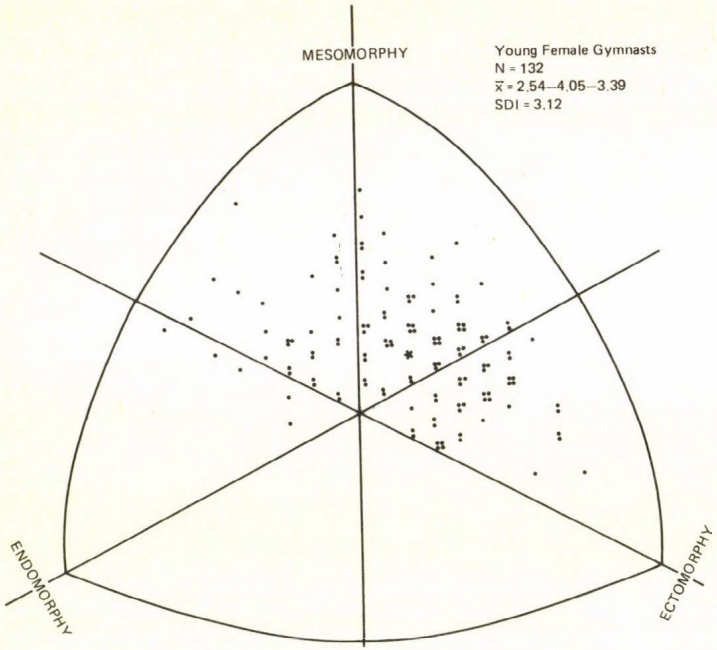

Fig. 4: Somatotypes of the female gymnasts

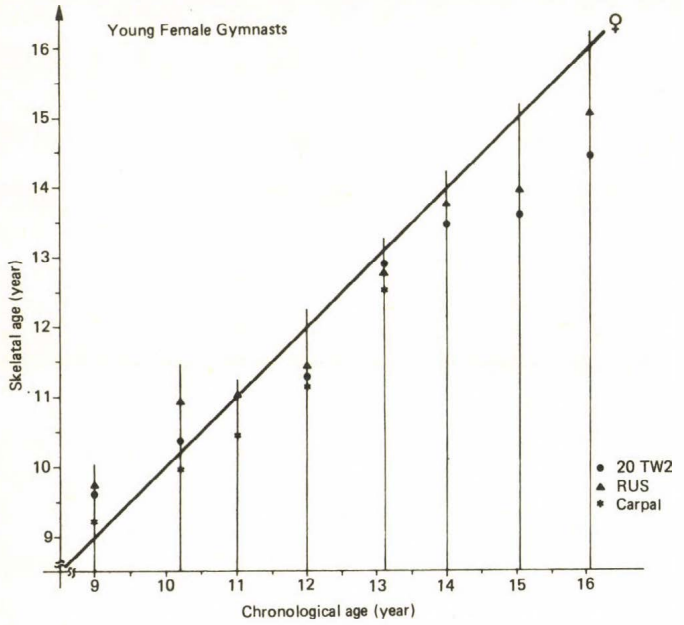

Fig. 5: Skeletal age of the female gymnasts compared to their chronological age

Table 2. Chronological age and skeletal age of the female gymnasts

Age (year)	N	Chronological age		Skeletal age 20TW2		RUS		Carpal	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
9	4	8.97	0.45	9.65	0.28	9.70	0.59	9.20	1.33
10	9	10.19	0.33	10.35	0.91	10.94	0.98	9.94	0.67
11	21	11.03	0.22	10.76	1.11	11.06	1.34	10.44	1.10
12	18	12.00	0.21	11.30	1.44	11.40	1.22	11.19	1.58
13	18	13.13	0.34	12.93	0.94	12.82	0.82	12.52	0.10
14	26	14.01	0.28	13.50	1.10	13.79	1.13	–	–
15	11	15.05	0.27	13.61	1.11	13.99	1.11	–	–
16	9	16.06	0.26	14.48	0.41	15.17	0.53	–	–

Menarche

The physiological maturation of the female gymnasts can be characterized among others also with age at menarche. The median of the investigated group is m=15.04±0.62 year which is extraordinarily late. The investigations carried out in the last decades in Europe and also in Hungary resulted in much earlier menarche medians of 12.6–13.0 year (Pantó 1980, Danker-Hopfe 1986a, 1986b). The Hungarian National Growth Study's female sample gave a median of m=12.89±0.10 year. Comparing the female gymnasts' median to these, they showed a late maturation by about 2.0–2.5 years.

It is also obvious that in the gymnasts the first onset of the menstruation was among the 13.5 year-old girls, while in an average population it usually appears at the age of 10.0–10.5 years. As it is well-known, menarche appears as the result of a certain developmental level of the cortex–hypophysis–ovarium system. R. E. Frisch observed that appearence of menarche postulated a body weight of 46–47 kg. Although her theory was thought to be controversial it is true that a critical weight and a certain developmental level of the neuroendocrine system are preliminary conditions of onset of menarche. The question is: whether the sport achievements are in proportion to the deleterious effect of the small body weight which can only be produced by a special diet. In the prepubertal and pubertal age where the investigated female gymnasts should belong on the basis of their chronological age, normally a significant growth spurt is detectable. This phenomenon usually appears in the means of height and weight. The intensive phase of growth needs a certain amount of food and especially the sufficient protein intake. One must suppose that the young female gymnasts did not accept all these. The great physical load of an especially hard training and the reduced protein intake as a part of a very strict diet (alimentary insufficiency?) hinder their biological maturation.

It is a well-known fact that menarche occurs during the descending branch of the height velocity curve, at the moment when the velocity dropping fastest. The female gymnasts investigated, because of their late maturation, produced a late and long-lasting pubertal growth spurt. This probably had an advantegeous effect on the load of their training and on their achievements.

When we adopt the old question: „Are athletes born or being made?" (Eiben 1972), in reference to our case we think that the intentional choice has an important role. We should suppose that trainers prefer children retarded in their growth who are supposed to have a late maturation. These children because of their rigorous training and special diet would be much more retarded than the normal children at the same age.

Summary

(1) The young Hungarian female gymnasts were less developed than their counterparts in their lenght, width and girth measurements. This retardation was undoubtedly caused by environmental and not by genetic factors.

(2) Their somatotype was mostly ectomorphic-mesomorph and in a minority meomorphic-ectomorph and balanced mesomorph.

(3) Their pubertal growth spurt and sexual maturation occurred 2.0–2.5 years later than those of their normal counterparts, and their skeletal maturation was also remarkably retarded.

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