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DEVELOPMENT OF PHYSICAL CHARACTERISTICS IN AN OLYMPIC WOMAN — CHAMPION IN HIGH PLATFORM DIVING

ABSTRACT. — The paper deals with the body development of an Olympic woman champion in high diving who took part in three successive Olympic games, won one gold and one silver Olympic medal, and was European champion. The study describes her development from childhood until adult age, from the beginnings of sport activity, over top performance, till the end of her sport career. Development of somatometric characters, indices of proportionality changes in body composition, characteristics of body type, changes in posture, muscles development, foot formation, development of biological age and of some functional features were followed in details. In this way it was possible for the first time to describe and by photosomatograms to document specific body characters in an outstanding sportswoman of world highest performance which were already given in childhood and which were only developed during following training.

To sum up we can say that body development of the Olympic woman champion studied from childhood, was in many ways positively adapted and was almost perfect.

Since a very long time we have been meeting inquieries as to what degree inborn physical characters in a sportsman are useful during an intensive performance and to what degree the specific adaptation of the organism is involved. We, however, haven't yet found in the literature any study describing changes in physical development of a sportsman of the highest world performance level from his childhood until adult age.

In the publications which are supposed to characterise how the organism is influenced by sport activity are usually described conditions in persons who have already reached certain sport efficiency (Correnti V., Zauli B. 1964, Hirata Kin-Itsu 1965, Hornof Z., Kremmer M. 1952, Jokl E. 1961, Maas G. D. 1974, Martinovská A. and al. 1966, Novotný V. 1958, Novotný V. 1968, Tanner J. M. 1964). It is hardly possible to characterise these results as consequences of sport activity as we do not know the initial physical condition. Such findings may be considered only as results of the examination of present physical condition of the sportsmen examined. To be able to comprehend more objectively the consequences of great physical load for the body development it is necessary to get results which document the course of development of investigated characters since the time before the beginning of competitive activity. Of course this is very difficult because one succeeds only scarcely to note the details of the development of an individual who later will reach exceptional succes. One must follow for many years many individuals who will never reach high efficiency level or who leave sport activity after several unsuccessful years.

We have succeeded to register the development of physical features of an outstanding Czechoslovak woman diver who took part in three successive Olympic games (Mexico 1963, Munich 1972, Montreal 1976) and on the two first named has won successively a gold and a silver medal, and in 1970 the title of European champion.

METHOD

The first examination was realized in 1960 when the girl was 8 years old and was beginning her sporting activity in diving. In her sport anamnesis she had already then preceeding two years preparation in modern gymnastics. At her first examination beside the basic clinical examination even the basic anthropometric and functional tests were carried out. At that time she had not yet decided whether she wants to compete in modern gymnastics or diving.

At the second examination in 1965 the young sports-woman was already 13 years old and has already specialized in diving. Beside the clinical examination a thourough examination of physical development and of some features of functional efficiency were carried out. These detailed examinations were then repeated at the age of 15, 19, 21, and 23 when she was slowly finishing her competitive activity and was concentrating on university studies. Some short examinations were carried out even between the mentioned years of age.

The detailed examination contained:

1. Sports anamnesis.

2. Somatometric examination.

a) Anthropometry of 48 body characters (after Martin R., Saller K. 1957), relative values of the measured body dimensions, indices of body proportionality, indices of Rohrer Pignet, Kaup, Brugsh-Seitz, and Livi-Hirata (Hirata Ki-Itsu 1965).

b) Determination of the amount of body fat and of weight of lean body mass (LBM) by means of an electronic capiler (Allen T. H. and al. 1956, Best W. R. 1954, Novotný V. 1971, Pařízková J. 1962, Pařízková J. 1977) and a single hydrometric determination of body composition by means of deuterium oxide (Novotný V., Ženíšek A. 1975).

c) Typological estimation by means of morphosomatograms (Correnti V., Zauli B. 1964).

3. Somatoscopic examination:

a) Objective estimation of body posture (Jaroš M. 1958).

b) Estimation of muscle development. Examination of foot arch by pedobaroscopy (Novotný V. 1971).

4. Somatographic examination:

a) Performing of photosomatogram in 4 projections (Novotný V. 1963).

b) Performing of cyrtogram of throrax (Nováková M. 1960).

c) Performing of plantogram and its evaluation by the method of Chippaux and Schwartz (Novotný V. 1965).

5. Biological age:

a) Growth age (Kapalín V. 1970).

b) Dental age (Škaloud F. 1979).

c) Skeletal age (Kapalín V. 1970).

d) Secondary characters (Tanner J. M. 1969).

6. Functional examination:

a) Spirographic examination of lung vital capacity, maximal breathing capacity, forced expiratory volume.

b) Heart rate.

c) Blood pressure (Syst. and Diast).

d) Harvard Step Test.

e) Hand grip strength.

As comparative material the results of the study of body development and fitness of Czech population in the frame of IBP (International biol. program) were used (Novotný V. 1973, 1978, Novotný V., Seliger V. 1980, Seliger V., Bartůněk Z. 1976).

RESULTS

1. *The anamnestic data* were given in the introduction of the paper.

2. *Somatometric examination:*

a) Basic data of growth of the studied sportswoman the high platform diver, are shown in *Table 1, 2,* and in *Fig. 1.*

Body height. When compared with girls of the same age of Czech population the studied sportswoman is short. Already at the first examination at the age of 8 when there was no question yet of any greater physical load, as to the height she was 1 SD under the norm and in this trend of growth she remained until adult age. The difference has grown somewhat between 8 and 13 years of age, on the other hand a higher speed in growth could be observed between the age of 13 and 15. Thus at the age of 16 (on the Graph Nr. 1. the period of Olympic victory is marked with an asterisk and of the silver Olympic victory with a cross) the difference got settled on the level of the first 8 years even during later maturity.

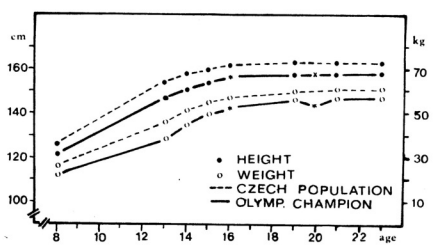


FIGURE 1. *Development of body height and body mass in Olympic woman-champion in high diving compared with the development in girls of general Czechoslovak population. An asterisk marks the period when she gained the golden Olympic medal, a cross when she gained the silver medal.*

TABLE 1

Age	Anthropometric characters of the woman Olympic Champion in high (platform) diving									
	13		15		19		21		23	
	Absolute values	Relative values	Absolute values	Relative values	Absolute values	Relative values	Absolute values	Relative values	Absolute values	Relative values
Body height [cm]	143,1		155.4		157.9		157.9		157.9	
Body mass [kg]	34.3	24.0	50.0	32.2	57.9	36.7	57.0	36.1	57.5	36.4
Lean body mass [kg]	30.6	21.3	42.2	27.1	45.7	28.5	45.7	28.9	45.2	28.6
Body fat [%]	11.0	7.7	15.7	10.1	22.3	14.1	19.9	12.6	21.4	13.6
Body height when sitting	74.2	51.8	82.6	53.2	84.0	53.2	84.0	53.2	84.0	53.2
Length of upper extremity	62.3	43.3	67.4	43.4	68.7	43.5	68.7	43.5	68.7	43.5
Length of lower extremity	79.7	55.5	85.1	54.8	86.5	54.8	86.5	54.8	86.4	54.7
Dist. dactil. — dactil. max.	142.0	99.2	156.5	100.7	158.5	100.4	158.5	100.4	158.5	100.4
Acromion	114.5	80.0	126.1	81.2	129.3	82.0	129.3	82.0	129.2	81.8
Jugulare	115.1	80.4	125.5	80.8	128.2	81.2	128.2	81.2	128.2	81.2
Radiale	88.8	62.0	96.4	62.1	98.2	62.2	98.2	62.2	98.0	62.1
Stylion	68.2	47.7	74.9	48.0	77.2	48.9	77.2	48.9	77.0	48.8
Dactylion	52.2	36.5	58.7	37.8	60.6	38.4	60.6	38.4	60.5	38.3
Illiocristale	87.3	61.0	93.8	60.5	94.2	59.7	94.3	59.7	94.4	59.8
Iliospinale ant.	83.3	58.2	89.1	57.4	90.2	57.2	90.4	57.2	90.4	57,2
Symphysion	76.0	53.1	81.0	52.2	82.4	52.2	82.5	52.3	82.4	52.2
Tibiale	40.9	28.6	44.0	28.3	44.8	28.4	44.0	27.9	44.2	28.0
Sphyrion	5.3	3.7	6.6	4.3	6.8	4.3	6.8	4.3	6.8	4.3
Dist. biacromialis	30.8	21.5	34.9	22.5	36.2	22.9	36.2	22.9	36.2	22.9
Dist. thor. transv.	22.3	15.6	25.4	16.4	26.4	16.7	26.2	16.6	26.0	16.5
Dist. thor. sagit.	16.4	11.5	18.4	11.9	19.2	12.2	19.2	12.2	19.0	12.0
Dist. bicristalis	21.6	15.1	23.5	15.1	24.3	15.4	24.4	15.5	24.4	15.5
Dist. bispinalis	19.0	13.3	20.4	13.1	21.0	13.3	21.2	13.4	21.6	13.7
Conj. externa	15.2	10.6	18.0	11.6	19.0	12.1	19.2	12.2	20.0	12.7
Dist. bitrochanterica	25.0	17.5	28.7	18.5	29.9	18.9	29.9	18.9	29.8	18.9
Dist. manu long.	14.4	10.1	15.8	10.2	16.4	10.4	16.4	10.4	16.4	10.4
Dist. manu transv.	6.7	4.7	7.3	4.8	7.5	4.8	7.5	4.8	7.5	4.8
Dist. pedis long.	21.9	15.3	22.7	14.6	23.1	14.7	23.1	14.7	23.2	14.7
Dist. pedis transv.	8.5	5.9	8.8	5.7	8.8	5.6	9.2	5.8	9.2	5.8
Circ. colli	29.2	20.4	32.8	21.1	34.1	21.6	33.5	21.2	33.6	21.3
Circ. thor. I. (mesost.)	74.0	51.7	84.5	54.5	87.0	55.1	86.8	55.0	86.8	55.0
Circ. thor. insp. I.	77.0	53.8	88.0	56.6	90.5	57.3	90.2	57.2	90.0	57.0
Circ. thor. exp. I.	72.8	50.9	81.0	52.0	83.0	52.6	83.0	52.6	83.0	52.6
Circ. thor. II. (xyphoid)	68.5	47.9	81.3	52.3	82.0	51.9	81.2	51.5	81.0	51.3
Circ. thor. insp. II.	73.0	51.0	85.0	54.7	85.9	54.4	86.0	54.5	86.0	54.5
Circ. thor. exsp. II.	67.8	47.4	78.0	50.2	78.0	49.4	78.5	49.2	78.4	49.7
Circ. abdominalis	60.0	41.8	68.2	43.9	73.0	46.2	74.0	46.9	75.0	47.5
Circ. glutealis	75.0	52.9	86.8	55.9	95.5	60.5	92.5	58.6	92.6	58.6
Circ. brach. dx. (relaxion)	22.1	15.5	25.8	16.6	29.8	18.9	29.0	18.4	29.0	18.4
(flexion)	23.3	16.3	26.2	16.9	31.2	19.8	31.2	19.8	31.0	19.6
Circ. brach. sin. (relaxion)	22.8	15.9	25.3	16.3	29.2	18.5	29.0	18.4	29.0	18.4
(flexion)	23.6	16.5	27.0	17.4	31.5	20.0	31.2	19.7	31.2	19.7
Circ. antebrach. dx.	20.9	14.6	24.9	16.1	25.0	15.9	24.8	15.7	24.4	15.5
sin.	20.8	14.6	24.7	15.9	24.9	15.8	24.5	15.5	24.2	15.3
Circ. fem. dx.	43.0	30.5	51.3	33.0	57.5	36.4	56.8	36.0	56.6	35.9
sin.	43.0	30.5	51.2	33.0	57.3	36.3	56.6	35.9	56.4	35.7
Circ. crur. dx.	29.0	20.3	33.1	21.3	35.2	22.3	35.2	22.3	35.2	22.3
sin.	29.1	20.4	32.9	21.2	35.2	22.3	35.2	22.3	35.2	22.3

Body mass. In comparison with general population the body mass is smaller, but the course of its changes was not so even as in body height. At the age of 8 her body mass had the value of 23.0 kg incomplete SD under the norm of general population, at the age of 13 the difference has risen to 1,5 SD, in the following years the difference began to level and since 18 the values of body mass remained slightly under the norm, with the exception of fluctuation at the age of 20 when before Olympic games a striking decrease of body mass occured.

The proportionality of body length. With regard to smaller body height the values of other body dimensions are influenced therewith and it therefore is more advantageous to assess the results in relative rather than in absolute values. The b o d y s i t t i n g h e i g h t position characterizes the length proportionality of the upper and the lower body segment. In the studied sportswoman the results until the age of 15 showed a distinct predominance of the length of the lower body segment compared with the upper segment, later, until adult age it corresponded to normal length proportionality in nor-

mal girls. The length of the upper extremity is relatively shorter until the age of 13, in the later periods on the level of norm. The length of the lower extremity is relatively on the level of values of control sample of girls until the age of 13, later, until adult age above norm. The intramembral index since childhood until adult age shows a moderate predominance in length of lower extremities in comparison with the upper ones.

TABLE 2. *Changes in indices of body proportionality in an Olympic woman-champion in high diving from 13 until 23 years*

Index of body proportionality	AGE				
	13	15	19	21	23
Thoracal I	136.0	138.0	137.5	137.5	136.8
Trunk breadth I	81.2	82.2	82.6	82.6	82.3
Pelvis breadth I	86.4	81.9	81.3	81.6	81.9
Intermembral I	78.2	79.2	79.3	79.4	79.5
Upper extremity circumferences I	105.7	103.6	119.2	116.9	118.9
Lower extremity circumferences I	67.4	64.5	61.2	62.0	62.3
Hand I	46.5	46.2	45.7	45.7	45.7
Foot I	38.8	38.8	38.1	39.8	39.7

Proportionality in body width. Biacromial diameter had an interesting development. Until 13 years of age it was distinctly under norm in absolute value, in relative value above norm. A great width of shoulders of the studied sportswoman is convincingly confirmed by the fact that in further years beside a relatively high value of the biacromial diameter even absolute value was permanently found above normal. The width of the chest brought similar results. Since childhood until adult age both absolute and relative values were higher than in general population. From 13 to 23 years the antero-posterior depth of chest was both absolutely and relatively above the norm. The thoracic index expresses the balance of breadth and depth of the thorax and during the whole course of development corresponds to the mean of general population, while with the general population it is reached under considerably lower values of breadth and depth of thorax. Distantia bicristalis is one of the number of parameters which characterize the proportionality of pelvis. The value of this body dimension in contrast to the thorax values were absolutely and relatively lower than the norm of girls of general population, while the difference was growing with the years. Distantia bitrochanterica in all followed age periods was in the absolute value deep under the norm, in the relative value it was at the same level with norm until the age of 19 of the sportswoman, then it remained on a permanent level, while in the norm there appears a rise. The trunk breadth index characterizes the breadth proportionality of the body of the studied sportswoman from 13 to 23 years of age and expresses in the course of followed years a very marked increasing prevalence of the shoulders breadth to that of the hips. The pelvis breadth index which shows the relation between bicristal and bitrochantric width, characterizes the pelvis of the studied woman as more widened from the bicristal towadrs bitrochantric width, while at the age of 13 the difference with respect to the norm was small and increasing from 13 to 23 years of age.

The proportionality of body circumferences. As with the dimensions of body widths and depths also with the body circumferences there are demonstrated in Table 1 more data than was possible to describe here. We will notice only those most important. The circumferences of the chest measured at mezosternal height are further proof of an exceptional chest development of the studied sportswoman. At the age of 13 the values are still slightly under norm. In all following age periods relative and absolute values of the chest circumference are above the norm of the general population. From the age of 15 this difference is very high. The difference of chest circumference in inspiration and expiration shows that at the age of 13 it was smaller than in the general population, from 15 years until adult age it remained at higher values than stated by the norm. The development of the chest circumference measured at the xiphoidal level has a similar character. At the age of 13 appears a distinctly smaller chest circumference than is the norm, from 15 to 23 on the contrary there were markedly bigger not only relative but also absolute values. Even the difference between inspiration and expiration at the xiphoidal level shows similar development. At the age of 13 there was found still smaller difference than in girls not going in for sports and markedly higher values from 15 years. The development of the abdomen circumference was smaller until the age of 19, and from 21 bigger than the norm of general girls. The gluteal circumference had also at first smaller values, from 19 it was approximately on the usual level in relative values. The circumferences of the upper arm relaxed and flexed were from 13 to 23 years of age bigger than given by the norm, while the difference in the sense of a bigger circumference in absolute and even relative value from 15 years of age was still increasing. The difference between the upper arm circumference in relaxation and flexion in the studied sportswoman was in the sense of bigger value and in the course of years was still increasing. The difference in the circumference values between the right and the left upper arm were without greater significance with the exception of their apparent equalizing in the course of the years of investigation. The development of forearm circumferences showed that they were markedly increasing from normal values compared with the presupposed norm at the age of 13, in the relative and absolute values they were high above general values. The differences between the right and left forearm were in no way significant. The index of upper extremity circumferences shows in this sense a marked predominance of the upper arm to the forearm which increased considerably since 19 years of age. The thigh circumference was in absolute and relative value under norm since the age of 15, it increased relatively since 19 years of age. The difference between the circumferences on the right and left side was without significance. The calf circumference at the age of 13 was both absolutely and relatively lower than the norm, from 15 to 25 years of age the absolute values were close to the norm but relatively they were above the norm. The lower extremity circumferences index testifies at the age of 13 and 15 for the prevalence of the calf in the sense of more slim thigh, from 19 to 23 years the index values equaled the general proportionality. The hand length is in all followed age periods relatively larger than in girls of general population. The foot length at the age of 13 and 15 is relatively at the general level, from 19 years it is both absolutely and relatively smaller than in the general population of girls.

The hand breadth is smaller until 15 years, in further years larger than in general population of girls. The hand index is low in all followed age periods, giving evidence of a longer and narrower hand.

The foot breadth from 13 to 23 years is near the norm, relatively slightly above the general average. The foot index in all followed age periods slightly above norm gives evidence of a rather shorter and wider foot.

b) Body composition: The results of body fat and lean body mass determination are presented in a survey in *Table 1* and *Fig. 2.* At the age of 13 and 15 a very small amount of body fat, deep under the values of girls of the same age of general population, at the age of 19 on the other hand a change to an increase of body fat above the general norm, then again before the Olympic games a drop under the norm, and at the age of 23 stabilization at the norm corresponding the norm of general population of girls. LBM was at the age of 13 both absolutely and relatively under the normal level, at the age of 15 and 19 a marked rise of LBM occured so that even with a small body height and body mass it equalled in the absolute value with general girls population and relatively it exceeded them considerably. The same trend was preserved even at the age o 21, later there appeared a decline in the LBM value. Close before the time of Olympic victory at the age of 16 the total body mass was 53 kg, the amount of body fat 17.45 %, LBM 43.75 kg. Before gaining the silver Olympic medal at the age of 20, the body mass was 54.90 kg the share of body fat 18.10, LBM 44.96.

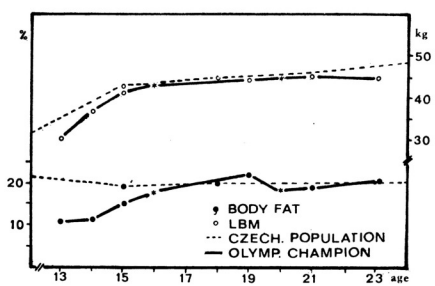


FIGURE 2. *Changes in the amount of body fat (%) and LBM (kg) in Olympic woman-champion in high diving compared with the values of general Czechoslovak girls. An asterisk marks the period when she gained the golden Olympic medal, a cross when she gained the silver medal.*

TABLE 3. *Body composition of the Olympic woman-champion in high (platform) diving (hydrometric examtnation).*

Age 21 yrs.			Body weight 57,0 kg		
TBW	(l)	34,55	LBM	(kg)	47,20
	(%)	60,60		(%)	82,80
Body fat	(kg)	9,80	Solids	(kg)	12,65
	(%)	17,20		(%)	22,20

The examination of body composition of the studied sportswoman by hydrometric method was done at the age of 21. The results are shown in *Fig. 3.* The total amount of body water was 60.6 %, solids 22.2 %, body fat 17.2 % which is less than determined at the same age by the caliper method (19.9 %), and on the contrary the amount of LBM 47.2 kg was higher than in the results determined by the caliper (45.7 kg).

TABLE 4. *The changes in the skinfolds thickness of the Olympic woman-champion in high diving.*

Skinfold (mm)	Age				
	13	15	19	21	23
Cheek	0,65	0,70	1,00	0,80	0,85
Chin	0,30	0,35	0,65	0,65	0,70
Chest I	0,30	0,40	0,40	0,45	0,45
Chest II	0,40	0,60	1,10	1,00	1,10
Abdomen	0,50	0,95	1,90	1,80	2,45
Side (suprailiac)	0,50	0,65	1,85	1,40	1,40
Back (subscapular)	0,50	0,90	1,40	1,25	1,45
Arm (triceps)	0,90	1,40	1,90	1,80	1,80
Thigh	0,80	0,95	1,35	1,00	1,00
Calf	0,40	0,90	1,35	1,10	1,10

The changes in the skinfold thickness in the course of growth and sport activity in the studied woman diver are presented in figures in *Table 4.* Until the age of 15 the skinfold was thinner on all places than in girls not going in for sports, since the age of 19 it was approximately at their level with the exception of the markedly small thickness of the abdomen skinfold.

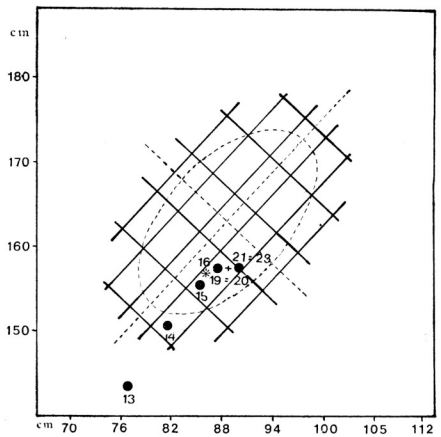


FIGURE 3. *Changes of morphosomatogram in Olympic woman-champion in high diving from 13 to 23 years. An asterisk marks the period when she gained the gold Olympic medal, a cross the period when she gained the silver medal.*

c) Body type: The characteristics of the primary features of body type of the studied Olympic woman champion in high platform diving and of the secondary influence of the specific life regime can be seen in the photosomatograms (Fig. 3, a, b, c) and in the morphosomatograms made by Correnti's method *(Fig. 4).* The individual stadia are marked in this figure by the data on age at which they have been reached. It is evident that during the development of the studied sportswoman the trend of eurimorphous type was preserved. At the time of Olympic victory the somatotype was distinctly eurimorphous hyposomnic, later it passed over to the range between euri- to ultraeurimorphous metrosomnic. The course of these changes is in accordance with the earlier given data on body proportionality and body composition. Primarily the somatotype of the sportswoman was characterized by small body height and body mass and by marked predominance of width and depth parameters of upper body segment which in the course of the followed years got still more expressive.

The development of body build as a whole is also characterized in the sportswoman followed by a number of indices (Rohrer, Kaup, Brugsh, Seitz, Pignet, Livi-Hirata), given in *Table 5.* At the index of Rohrer and Kaup even the count over to LBM amount was used, which enables a more accurate assessing of the values of these indices without the share of body fat in the total body mass (Hornof Z., Novotný V., 1967).

TABLE 5. *Indices of body structure of the Olympic woman-champion in high diving from childhood until adult age.*

Index	AGE				
	13	15	19	21	23
Rohrer	1,17	1,33	1,47	1,45	1,46
Rohrer (LBM)	1,04	1,12	1,14	1,16	1,15
Kaup	1,67	2,07	2,32	2,59	2,31
Kaup (LBM)	1,49	1,75	1,80	1,83	1,81
Brugsh-Seitz (b-index)	51,71	54,38	55,10	54,97	54,97
Pignet	18,33	18,99	18,70	18,77	18,72
Livi-Hirata (F-index)	22,71	23,68	24,51	24,38	24,45

3. *Somatoscopic examination:*

a) *Posture:* Survey of the results of posture examination on 6 parts of the body is presented in *Table 6.* Standing position of head, neck, shoulders, the chest formation, abdomen and its posture, were perfect during the whole time. At the age of 13 a bigger incline of the pelvis was noticed, a slight asymmetry of the height of shoulder muscles, scapulae alatae, which were leveling from 15 years, increased lumbar lordosis which outlasted more markedly even at the age of 19. In the period between 19 and 23 the posture was almost perfect. On the lower extremities since childhood a sign of genua valga, the foot formation showed a slight transversal flattening at 13 and 15 which hasn't been registered in later years.

TABLE 6. *Results of somatoscopic evaluation of the posture of the Olympic woman-champion in high diving from 13 till 23 years. (Classification: 1 = perfect, 2 = good, 3 = bad, 4 = quite bad).*

Evaluated parts of posture	AGE				
	13	15	19	21	23
	Classification				
Head, neck	1	1	1	1	1
Chest, shoulders	1	1	1	1	1
Abdomen, pelvis	2	2	1	1	1
Curve of backbone (antero-post.)	2	2	2	2	2
Position of trunk (frontal plane)	2	2	1	1	1
Lower extremities	2	2	1	1	1

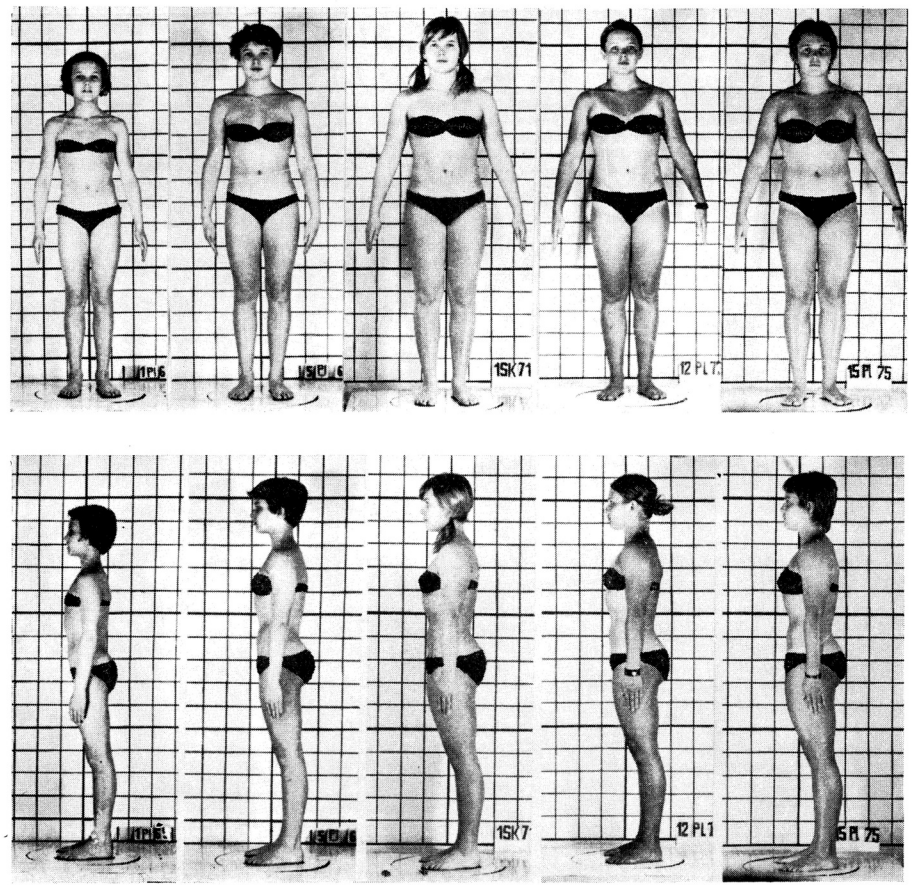
b) *Pedobaroscopic examination* showed with gradually increasing clearness in the heads of I.—IV. metatarsus to the formation of posture with a larger load on the foremost part of the foot sole. At the same time a retreat of the edge of the foremost half of inner arch of foot sole pressed by body mass to the pedobaroscop, has been noticed.

c) *Development of muscles:* At the age of 13 the development of muscles is described in the examination records as very weak. Slightly marked were only mm. pectorales and m. latissimus dorsi. At the age of 15 the musculature in these parts of body got considerably more marked and joined by distinct increase of arms and calves muscles. Since 19 years considerable development of the musculature of trunk and extremities was evident but it was disappearing more and more under the subcutaneous fat layer. A distingt development of back muscles in the studied sportswoman was characteristic from childhood until adult age.

4. *Somatographic examination:*

a) *Photosomatogram:* Photosomatogram in 3 projections *(Fig. 4a, b, c)* made in all periods of examination from 13 until 23 years makes possible objective documentation of results of the studied woman high platform diver body development evaluation from the beginning of her competitive activity in high diving over the top of her sport efficiency with the Olympic victory, till the gradual diminishing of training load and even of efficiency. From the photosomatograms a positive trend in posture

Fig. 4a, b



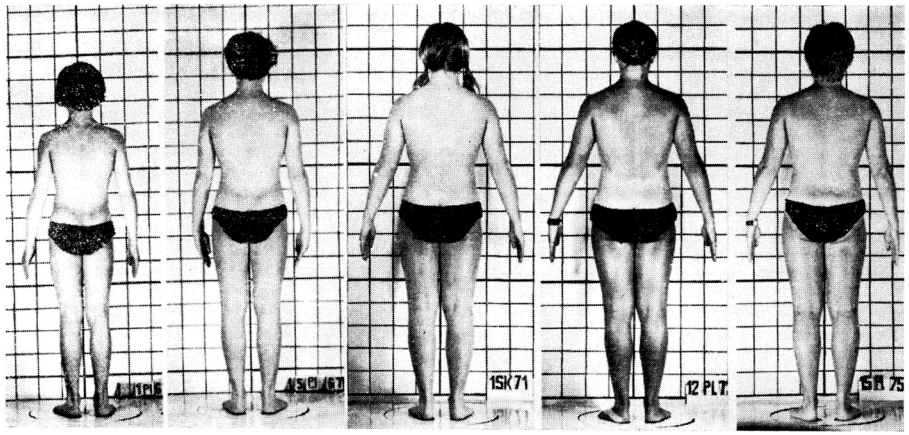


FIGURE 4. *Photosomatograms of Olympic woman-champion in high diving which are a documentation of body development of outstanding sportswoman from 13 years, when she was beginning her sporting activity until 23 years when the intensity of the load and efficiency were decreasing.*

Fig. 4c

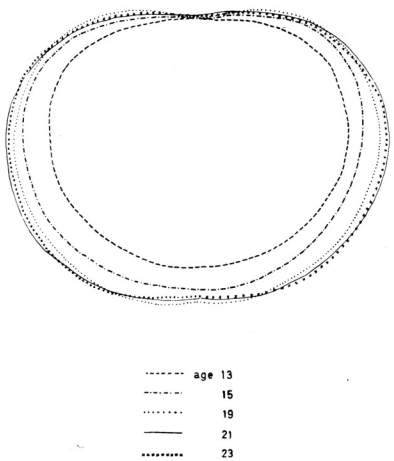


FIGURE 5. *The changes of chest development from 13 to 23 years in Olympic woman-champion in high diving are documented by cyrtograms of the chest.*

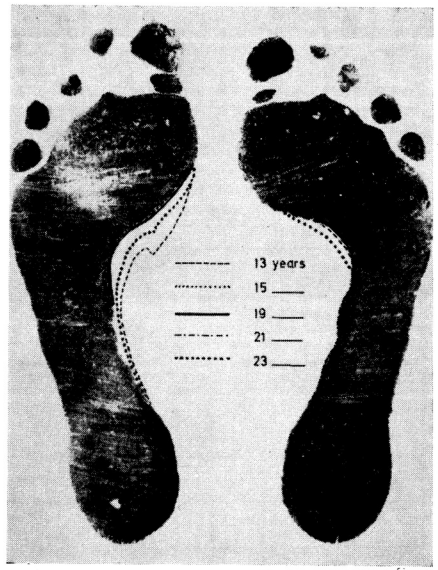


FIGURE 6. *The plantograms are a documentation of the changes in foot formation from 13 to 23 years in Olympic woman-champion in high diving.*

during the competitive activity, a characteristic development of musculature even a later development of subcutaneous fat layer, are also apparent. With the photosomatograms it is possible to document how a girl which was very gracile for the age of 13, was changing in the course of years into a robust woman with a very good body development.

b) *Cyrtogram of the chest* of the sportswoman made in all the followed periods documents the development of the chest shape. Since childhood a well arched chest was developing harmoniously in width and depth. Cyrtograms (Titlbachová S., Novotný V., 1966) have thus completed somatometric data measured at the mezosternal level, whereas cyrtography was carried out at the xiphosternal level *(Fig. 5)*.

c) *Plantogram:* Was also taken at every examination from 13 till 23 *(Fig. 6)*. In childhood a lowering of the foot arch especially of the left was apparent. A gradual improvement of the foot formation especially of the transversal foot arch is apparent not only from the plantograms but even from numerical results *(Table 7)*. Index of Chippauxe describing the longitudinal arch didn't practically change in the right normally arched foot, in the left foot it was gradually lowering and thus indicating improvement of the arch. The Schwartz's angel evaluating the transversal arch didn't change considerably in the right foot either from 13 to 23 years, in the left foot — the arch of which was transversaly lowered in the childhood, showed distinct improvement towards normal.

TABLE 7. *Results of the foot arch examination according to the plantograms from 13 till 23 years of the Olympic woman-champion in high diving.*

Method	Age	Foot	
		right	left
Index of Chippaux	13	29.2	39.0
	15	31.5	38.5
	19	33.7	36.8
	21	34.1	36.2
	23	30.0	35.6
Angle of Schwartz	13	42°	28°
	15	39°	34°
	19	43°	39°
	21	43°	40°
	23	44°	40°

5. *Biological age:*

The development of biological age in the studied outstanding woman diver, is presented in *Table 8*. In comparison with the chronological age already at the age of 13 years, at the beginning of the intensive competitive activity, it showed retardation in growth and dental age, even in the development of secondary sexual characters approximately by one and a half of a year. At the of 15 the retardation in growth has somewhat decreased, in the dental age on the contrary it has increased. The skeletal age and maturity of secondary characters corresponded to age younger by six months. E.g. the distal phalanx of the thumb was only finishing its fusion, the proximal phalanges of thumb and other fingers were only beginning their fusion, the epiphyses of radius and ulna were only at the stage of capsuling.

TABLE 8. *Evolution of biological age in an Olympic woman-champion in high diving.*

Chronological age	12.9	14.9	16.2	18.9
Dental age	11.7	12.1	16.2	18.9
Morphological size age	11.2	14.0	14.6	16.9
Sexual maturation age	11.5	13.5	16.2	18.9
Skeletal age	—	13.3	—	17.6

At the age of 16 (Olympic championship) a small body growth (apparent already since childhood) of the studied sportswoman began to be remarkably apparent which resulted in a false impression of growth retardation. Other characters of biological age correspond already to the chronological age, the skeletal age at 16 was not registered. At the age of 19 the body heigth remained at low values and therefore even the growth age appeared as if retarded by 2 years, the skeletal age, however, was really in the stage of maturation which could be expected already at the age of 17. Epiphysis of the radius was only finishing the fusion.

6. *Functional examination:*

Results of functional examinations in this place are only of general information. That is why on the *Table 9* are only basic results presented which complete a detailed analysis of the studied sportswoman body development. The spirographic examination shows that vital capacity (VC) at the age of 13 was under the level of general girls both in absolute value as well as in percentage in relationship to individual body factors. At the age of 15 a marked turn towards development of VC appeared and in both evaluation criteria it highly surpassed the values of girls of general population. The highest values were gradually reached at the age of 21, later only a decline was registered. It was likewise with the values of *maximal breathing capacity* (V_{max}) where highest values were reached at the age of 19. Results of examination of forced expiratory volume (FEV) were entirely at the level of healthy normal subjects. The decline of values FEV_{1sec} and FEV_{2sec} is connected with the development of VC in the course of years.

The heart rate corresponds to general norms, in the course of development a rising tendency to bradycardy can be seen. The blood pressure both systolic and diastolic remained at optimal unchanging level from childhood until adult age. The Harvard step test made at the age of 16 corresponded to a very good functional efficiency. The same level had even the result of

TABLE 9. *Development of basic functional tests in Olympic woman-champion in diving from 13 to 23 years.*

Examination	AGE				
	13	15	19	21	23
VC (ml, BTPS)	2 430	3 650 *3 750	3 800 ×3 900	3 950	3 710
VC (% VC theor.)	94.6	112.8 *114.6	115.5 × 126.5	123.1	115.1
$\dot{V}_{max}$ (ml, BTPS)	89 700	99 000 *106 200	117 800 ×114 000	96 900	92 300
FEV_{1sec}	86.5	84.0 *85.2	77.0 ×80.1	76.0	74.8
FEV_{2sec}	94.7	90.0 *92.6	92.3 ×92.4	90.1	90.2
FEV_{3sec}	97.8	96.0 *98.0	96.1 ×97.2	95.0	98.2
f_h	72	72 *70	72 ×68	64	60
BP syst.	110	110 *115	120 ×120	115	110
BP diast.	70	70 *70	80 ×75	70	70
Harvard step-test	—	104 *101	— ×115	—	—
Hand grip strenght dx	20	26 *27	29 ×30	30	32
sin	15	24 *24	29 ×29	27	31

With an asterisk are marked the results got closely before gaining the golden Olympic medal, with a cross the results got before gaining the silver medal.

step test made at the age of 16 close before the Olympic championship. The hand grip strength had a similar development just like a number of other indices in the sportswoman studied. At the age of 13 the values were under the norm of general girls, at 15 the norm was equaled and surpassed in later years.

On the whole the results of the most basic functional examination showed a normal level slightly above the norm and in the course of years from childhood to adult age a favourable development trend.

DISCUSSION

After a number of papers presenting a picture of body build of outstanding sportsmen (Baškirov P. N. and al. 1968, Klaus E. J. 1953, Kohlrausch W. 1930, Novotný V., Titlbachová S. 1956, Novotný V., Tamassyová E. 1967, Šabat K., Novotný V. 1961, Tittel K., Wutscherk H. 1972), so far this study of body characters development of Olympic woman champion from childhood until adult age, i.e. from the beginning of sport activity, over the top of sport efficiency, till the close of sport activity, is a unique example. The study makes possible an objective finding about what in the body build of the outstanding woman diver is typical, what could contribute to exceptional performance, which of the characteristic features existed from the beginning and which developed only during the years of development and intensive sport activity.

On the first place the shortness of the outstanding sportswoman is striking. From the evaluation of length proportionality it is apparent that the initial slight length predominance of the lower body segment compared with the upper in the course of years got almost equal, and that in this direction there was nothing in the sense of predisposition, neither in the further course of development, which could be determined, beside the small body heigth, as characteristic for high diving.

In the width proportionality there was already possible to observe certain pecularities, before all in the sense of the width predominance of upper body segment compared to the lower. This predominance could be observed already at the beginning of sport activity and in the course of years it was still increasing. Considering that the foot plays an important part in the performance of a woman diver, it is of interest that its proportionality indicates rather a short and wider foot. In the proportionality of body circumferences it is possible to notice an insignificant predispositional factor in a larger chest circumference, in the course of years, however, strongly influencing the circumferential parameters during the sport training in the sense of higher values.

As to the body composition of the sportswoman studied, her thinness at the beginning of sport activity is remarkable and later in the period of top performance a relatively large quantity of body fat which was changing according to the intensity of the momentary training situation. Before the Olympic games a decline of the amount of body fat is seen and then again return to general values or even higher values than in general girls. In all this a characteristic phenomenon is that in the place of the usually largest fat layer, i.e. on the abdomen, the studied sportswoman had even with larger amount of total body fat a very thin skinfold. It is clearly connected with the specific sport training which requires a high almost a gymnastic skill. The described characteristic body features document, in a complex way, the body type which in the course of years was getting a specific character, rising of robustness, muscle hypertrophy, later a greater amount of body fat. This trend is shown both by the applied Correnti's typology as well as the presented indices in which e.g. Pignet's index designates the sportswoman's body type from childhood until adult age as robust, till the casual evaluation of the type by Sheldon's method which constantly determines her as a mezomorph, mezomorph ectomorphic in childhood, and mezomorph endomorphic in adult age. The photosomatograms are a unique objective evidence of body features development of the Olympic champion from the beginning of sport activity until its end. Biological age developed normally in most of the indices, the observed retardation in skeletal age maturation is possible (even when examinations at the age under 15 years are missing) to attribute according to the experiences so far, to the individual development trend of later maturation which probably started already in childhood. With regard to other indices it isn't therefore possible to consider the retarded skeletal age development as a consequence of intensive sport load. Data on functional examination complete only the characteristics of the studied sportswoman. With regard to their limited extent they afford no possibility to estimate different aspects of functional efficiency. In ventilative values they are signs of possibilities above average which were gradually diminishing with the decreasing load intensity. The results of cardiovascular tests correspond to normal values occasionally showing functional efficiency slightly above average. With regard to the physical load type in diving it is nevertheless possible to assume that even demanding spiroergometric examination would not bring signs of unusual functional efficiency, because — as in a number of other sport disciplines — the performance in diving is not dependent on exceptional efficiency of cardiopulmonary system.

The examination of sportsmen is done first of all from the point of view of health and sports. The main goal is the determination whether the sportsman by his state of health and functional fitness is able to cope with great sport load without negative consequences. This is connected with anthropological examination which estimates body presumptions for a certain sport performace as well as for the course of body features development during high physical load. In this paper we tried to answer some of these questions on the example of an Olympic woman champion in high diving. It is pleasant to state that in the case of the outstanding sportswoman studied the findings were mostly favourable, improving since childhood and at the end of her exceptionally successful sport career it was possible to designate her body development as almost perfect.

REFERENCES

ALLEN T. H., PENG M. T., CHEN K. P., HUANG T. F., CHANG C. and FANG H. S., 1956: Prediction of total adiposity from skinfold and the curvilinear relationship between external and internal adiposity. *Metabolism*, 5: 346—352.

BAŠKIROV P. N., LUTOVINOVA N. J., UTKINA M. I., ČTECOV N. P., 1968: *Strojenie tela i sport*, MGU, Moskva.

BEST W. R., 1954: An improved caliper for the measurement of skinfold thickness. *J. Lab. Clin. Med.*, 43: 967—970.

CORRENTI V., ZAULI B., 1964: *Olympionici*. Roma.

HIRATA KIN-ITSU, 1965: *Physique and age of Tokio Olympic Champions*. Tokyo.

HORNOF Z., KREMMER M., 1952: Biologický podklad výkonů světového rekordmana Zátopka. *Sokol*, 72, 167.

HORNOF Z., NOVOTNÝ V. 1967: Velikost srdce veslařů a její vztah k aktivní tělesné hmotě. *Tělovýchovný sborník*, 10: 17—28.

JAROŠ M. 1958: Držení těla očima lékaře. In: Berdychová J., Jaroš M., Škvára F.: *Výchova k správnému držení těla*. Praha.

JOKL E., 1961: Three Olympic champions. In: Health and Fitness in the modern world. *Am. Col. of Sports. Med. Madison*.

KAPALÍN V., 1970: Hodnocení úrovně růstu a dalších biologických předpokladů zvyšování zdatnosti dětí a mládeže. In: Choutková B., Kučera M.: *Mládež a sport*. Olympia, Praha.

KLAUS E. J., 1953: *Weibliche Konstitution und Sport*. Univ. Münster. Münster.

KOHLRAUSCH W., 1930: Zusammenhänge von Körperform und Leistung. *Arbeitsphysiologie*, 2, 187.

MAAS G. D., 1974: *The physique of athletes*. Leiden Univ. Press. Leiden.

MARTIN R., SALLER K., 1957: *Lehrbuch der Anthropologie*. Stuttgart.

MARTINOVSKÁ A., NOVOTNÝ V., TAMASSYOVÁ E., TREFNÝ Z., 1966: État morphologique et fonctionnel des championnes mondiales de gymnastique moderne. *XVI. Weltkongress für Sportmedizin, Berichte „S" II. Teil*, 566—580, Hannover.

NOVÁKOVÁ M., 1960: Sledování změn tvaru hrudníku při některých onemocněních v dětském věku. *Čs. pediatrie*, 15: 8.

NOVOTNÝ V., 1963: Metodika fotografování při sledování tělesného rozvoje. *Příručka o kritériích výkonnosti*, ČSAV Praha, 19—22.

NOVOTNÝ V., 1965: Beitrag zur Problematik der Fusssohlenwölbung der derzeitigen Hochschuljugend. *Acta Univ. Carol. Biol. Suppl.*, 35—42.

NOVOTNÝ V., 1971: Zjišťování tělesného rozvoje. In: Kolektiv, *Praktikum z tělovýchovného lékařství*. St. ped. nakl., Praha.

NOVOTNÝ V., 1971: Electronic digital skinfold calliper and its application in the sports anthropology. *I. Anthropological Congress of A. Hrdlička,* Academia Praha, 271—275.
NOVOTNÝ V., ŽENÍŠEK A., 1975: Stanovení tělesného složení pomocí 2 H_2O a jeho užití v tělovýchovném lékařství. *Teor. a Praxe těl. Vých.,* 23: 500—504.
NOVOTNÝ V., 1958: Příspěvek k antropologii nejlepších evropských boxerů. *Teorie a Praxe těl. Vých. a sp.,* 16—22.
NOVOTNÝ V., TITLBACHOVÁ S., 1956: Marques caractéristiques chez les femmes sportives et point de vue somatométrique. *XI. Congrés internat. de medecine sportive,* Luxembourg, 405—412.
NOVOTNÝ V., TAMASSYOVÁ E., 1967: Tělesný rozvoj nejlepších světových veslařů. *Tělovýchovný sborník,* 10: 4—17.
NOVOTNÝ V., 1968: The anthropological profile of a world lady champion in modern gymnastics. *Anthropologie,* 6: 43—50.
NOVOTNÝ V., 1973: Množství tělesného tuku u vzorku české populace ve věku 12, 15, 18 a 25 let. *Čas. lék. čes.,* 39: 1188—1194.
NOVOTNÝ V., 1978: Tělesné složení u žen s různou pohybovou zátěží. *Čs. gynekologie,* 43: 94—97.
NOVOTNÝ V., SELIGER V., 1980: Tělesný rozvoj současné čs. populace. *Lékař a tělesná výchova,* 10—17.
PAŘÍZKOVÁ J., 1962: *Rozvoj aktivní tělesné hmoty a tuku u dětí a mládeže.* St. zdrav. nakl., Praha.
PAŘÍZKOVÁ J., 1977: *Body Fat and Physical Fitness.* M. Nijhoff, Hague.
ŠABAT K., NOVOTNÝ V., 1961: Die anthropometrische Untersuchung der besten europeischen Volleyballspieler. *Med. Sport,* 1, 33—46.
SELIGER V., BARTŮNĚK Z., 1976: *Mean values of various indices of physical fitnes in the investigation of Czechoslovak population aged 12—55 years.* ČSTV, Praha.
ŠKALOUD F., 1980: Criteria for tooth age evaluation in contemporary population. *Methods of functional anthropology. Charles University Press, Prague,* 249—251.
TANNER J. M., 1964: *The physique of the Olympic athlete.* G. Allen and Unwin LTD, London.
TANNER J. M., 1969: Puberty rating. In: Weiner J. S., Lourie J. A., *Human biology, IBP Handbook* No 9, Oxford.
TITLBACHOVÁ S., NOVOTNÝ A., 1966: Tělesná práce ve sportu a vývoj tvaru hrudníku. *Acta F. R. N. Univ. Comen.* X. S. Anthrop., 11: 199—205.
TITTEL K., WUTSCHERK H., 1972: *Sportanthropometrie.* J. A. Barth, Leipzig.

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