PROGNOSIS OF TRAINING EFFECTS BASED ON SOMATIC CHARACTERISTICS AND SPORT RESULT

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Abstract. *Purpose*: Researchers and coaches continue to look for the solutions that would contribute to creation of somatic and mobility condition patterns, allowing the players to obtain sport achievements at the highest level. Therefore, the aim of the study was to trace the sport results' impact in the pole vault and the selected somatic parameters of the vaulters of different ages and comparing them with the results of the players reaching the results at the highest level. *Material:* The study covered 29 vaulters of 17-19 years old age, engaged in the pole vault at "Zawisza Bydgoszcz", "Gwardia" Pila, "Sląsk" Wrocław, TS "Olimpia" Poznan sports clubs, the Centre of the Pole Vault in Gdańsk, as well as 4 top vaulters - two from Germany, one from the UK and one from Poland. The study was carried out in the training and sports competitions conditions in 2005-2009. In the work teaching observation method was used. The research tools were: assessment of physical development and sports outcome, which were carried out within the start period. The statistical methods were used for analysis of the study results. *Results*: Indicators of physical development were specified, as well as correlated with sport result for each group. The highest (the only statistically significant) indicator with the pole vault at 0.69 level was reported in the sample - the volume thoracic, exhaling (19-year-old vaulters). *Conclusions*: The group of vaulters, belonging to the "world's finest" is characterized by a higher rate of shoulders than the other studied groups. There seems to be a large influence on sport technique and result in the pole vault belonging to the proportions of the individual somatic parameters and here the relevant connections can be seen.
Keywords: physical development, comparison, pole vault, somatic.

Introduction

The researchers and coaches continue to look for solutions that would contribute to creation of somatic and mobility condition patterns, allowing the players to obtain sport achievements at the highest level. Of course, these achievements are possible with a parallel adjustment and optimizing of means and training methods to individual psychophysical predispositions of a vaulter, properly trained body wellness, as well as control of its responses[1, 2, 3, 4].

Individual sport disciplines are closely associated with specific requirements, for example somatic (basketball player, swimmers, gymnasts, strongmen, vaulters), which can be used to achieve sports outcome at the highest level.

The pole vault belongs to a very interesting competition in athletics, but execution of the pole vault is associated with a number of complex sequences of movements. They include - optimal speed of running start and transfer of kinetic energy to pole in order to use it to move the body on the flexible pole vault up and take the bar suspended as high as possible [5]. Only athletes with special skills such as: orientation in time and space, body balance, proper psychomotor and somatic conditions, can meet these criteria [6, 7, 8].

On the basis of carried out control of suitability, we receive the necessary message regarding their current level, which will serve for planning of training loads and sport result [5, 9, 10].

Analysis of specialized literature permits to conclude that type of body of every person is his/her biological characteristic of large genetic determinants of significant stability during its ontogeny [11, 12, 13]. Therefore, the choice of individual sports disciplines for certain somatic built plays important role, and in the future it will allow to take part in competitions at the highest level. According to the researchers the somatic built, especially some of its proportions, have a specific track of its development, particularly important in the pole vault [11, 14]. Unfortunately, at present it is difficult to determine, which of the parameters of somatic built can serve as a criterion for sportsmen of all ages, training the pole vault.

Therefore, the aim of the study was to trace the impact of the sport result on pole vault and the selected somatic parameters of different age vaulters as well as comparing them with the results of sportsmen, who already reached the highest results.

Material and methods

The study was carried out in training conditions and sports competitions in 2005-2009. It involved 29 sportsmen of 17, 18 and 19 years old age, engaged in the pole vault at "Zawisza" Bydgoszcz, "Gwardia" Piła, "Śląsk" Wrocław, TS "Olimpia" Poznań sports clubs, the Centre of the Pole Vaulter Gdańsk, as well as four athletes, two from Germany, one from the UK and one from Poland, whose best result in pole vault varied from 571 to 600 cm (later herein this group of four vaulters is specified as "Group A").

17, 18, 19-year-old athletes attended club training courses, 5-7 times a week. The training unit was 60-120 min., while at school they were taught by the program of physical education in terms of 3-4 classes a week, focused on development of overall physical fitness. While the players of "Group A" trained from 6 to 11 times a week. The training unit was 120 min.

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In our work we used the following methods and research tools:

- assessment of physical development,
- registration of athletic result,
- statistical methods.

In order to carry out assessment of physical development, the measurements of somatic built were conducted, with registration of the following indicators:

- body height (basis-vertex),
- body weight,
- torso length (suprasternale-symphysiom),
- lower limb length (basis-symphysion),
- upper limb length (acromion-daktylion III),
- shoulder width (acromion-acromion),
- pelvis width (iliocristale-iriocristale),
- thigh circumference,
- shank circumference,
- arm circumference,
- volume of the chest during inspiration,
- volume of the chest during exhalation,
- chest breadth (the difference of the chest volume during inhaling and exhaling).

With these parameters the somatic built ratio was calculated according to Rohrer, by determination of the ratio of body weight and height.

$$\text{weight it its height} = \frac{\text{body weight (g)} \times 100}{\text{body height (cm)}\ 3}$$

$$\text{- indicator of bars} = \frac{\text{width of bars}}{\text{length of the torso}} \times 100$$

$$\text{- indicator of the pelvis} = \frac{\text{width of the pelvis}}{\text{width of bars}} \times 100$$

Large bow compass, medical weight and metric tape were used to carry out the study.

For the analysis of athletic result the protocols of official competitions were taken into account. The collected material was statistically analysed using the values of minimum, maximum and average variance of the studied parameters, and Pearson correlation coefficients was found to be statistically significant at $p<0.05$.

Analysis of the studied results

The carried out analysis of physical development of 17-19-year-old vaulters showed fluctuations in the value of the standard deviation of each parameter of 1.04 cm (arm circumference of 18-year-old participants) to 6.10 cm (length of the lower limb of 19-year-old participants) (Table 1).

The average height of 19 years old participants was 186.78 cm. The highest vaulter was characterised by the body height of 191 cm, while the lowest was 175 cm. The average body mass of 17-year-old trainees was about 69.97 kg, in this group the greatest dispersion of results can be noted as well (standard deviation of 5.39).

Mean value of the shoulder width, e.g. in the group of 17-year-old vaulters, was 39.95 cm, hip width - 30.5 (18-years' age). The most significant difference between the smallest and the largest values of the shoulder and hip width in each group was respectively 7.2 cm (17-years' age) and 8.0 cm (19-year-old vaulters).

While mean values of lower and upper limbs' length, for example, in group of 18-year-old athletes was 91.16 cm and 78.97 cm.

The measurements of thighs' circumference, lower leg and arm were also interesting. Mean values of these parameters of e.g. 17-year-old vaulters were respectively 50.4 cm, 36,08 cm and 27,85 cm. The largest difference in standard deviation occurred was in circumference of the thigh of 19-year-old (4.59); maximum value of this indicator was 61 cm and minimum - 45 cm.

The measurement of the volume of the chest when at inhale/exhale and size of chest, e.g. in group of 18-years'-old, showed the average value respectively at level of 96.89 cm, 88.61 cm and 8.28 cm.

Average torso length, e.g. of 17-years'-old, was 54.78 cm; the difference between maximum and minimum values was 5.8 cm.

On the basis of this analysis of the somatic parameters of the vaulters, the dependencies were revealed, which derived from their natural biological development and the process of organism's adaptation under the influence incentives (load training).

Table1.

Parameters of the somatic built of 17-19 years' old vaulters (source, Klimczyk, 2012).

Parametres	Statistical quantities	17 years old (n-11)	18 years old (n-9)	19 years old (n-9)
body height (cm)	M	182,73	183,00	186,78
	SD	5,14	6,04	4,94
	Min	174,00	174,00	175,00
	Max	190,00	189,00	191,00
body weight (kg)	M	69,97	71,90	76,58
	SD	5,39	5,30	4,46
	Min	60,00	60,00	69,00
	Max	76,00	77,50	84,00
shoulder width (cm)	M	39,95	40,42	42,34
	SD	2,24	1,99	1,77
	Min	36,70	36,70	39,60
	Max	43,90	43,10	45,00
pelvis width (cm)	M	29,37	30,50	30,66
	SD	1,48	2,51	2,61
	Min	27,70	27,70	26,00
	Max	32,50	34,20	34,00
lower limb length (cm)	M	92,57	91,16	95,02
	SD	3,32	5,86	6,10
	Min	84,00	83,40	84,00
	Max	96,50	98,00	101,00
upper limb length (cm)	M	80,21	78,97	81,28
	SD	2,86	4,02	3,56
	Min	75,00	73,00	74,00
	Max	84,20	84,00	85,00
thigh circumference (cm)	M	50,40	50,94	54,11
	SD	4,20	3,91	4,59
	Min	45,30	43,00	45,00
	Max	58,00	56,00	61,00
Shin circumference (cm)	M	36,08	35,61	37,83
	SD	2,31	1,88	1,30
	Min	33,00	33,00	36,50
	Max	40,00	38,00	40,50
arm circumference (cm)	M	27,85	28,06	29,78
	SD	1,99	1,04	1,68
	Min	25,50	27,00	27,50
	Max	32,00	29,50	32,50
volume of chest after inhalation (cm)	M	95,77	96,89	101,94
	SD	4,22	4,57	4,98
	Min	90,00	90,00	95,50
	Max	101,50	103,00	112,00
volume of chest after exhalation (cm)	M	87,59	88,61	92,33
	SD	4,01	4,53	3,87
	Min	80,00	80,00	88,00
	Max	93,50	92,50	101,00
chest breadth (cm)	M	8,29	8,28	8,83
	SD	1,97	1,95	1,77
	Min	7,00	5,00	6,00
	Max	11,00	11,00	11,00
torso length (cm)	M	54,78	55,18	56,50
	SD	1,93	2,48	2,15
	Min	51,30	51,00	55,00

	Max	57,10	60,20	62,00

Correlation analysis demonstrated relationship between different parameters of the somatic built and showed significant interdependencies. In all age groups with the highest coefficients of dependence were between height and weight (0.52 to 0.90). Very high dependence was found between volume of chest at inhale/exhale (correlation coefficient of 0.80 to 0.96). In the age group of 17-19 years old, the significant differences, concerning correlation, were not found. The higher range (0.63-0.96) was detected only between few parameters. Below the correlation of somatic dimensions, e.g. 19-year-old vaulters, is shown.

Table 2

Correlation matrix of somatic dimensions of 19-year-old vaulters.

Studied parameters	**Lp.**												
body height (cm)	**1.**												
body weight (kg)	**2.**	0,52											
shoulder width (cm)	**3.**	-0,04	0,42										
pelvis width (cm)	**4.**	-0,44	0,29	0,09									
lower limb length (cm)	**5.**	**0,88**	0,22	-0,01	-0,62								
upper limb length (cm)	**6.**	0,60	0,10	**-0,74**	-0,24	0,50							
thigh circumference (cm)	**7.**	0,05	**0,72**	0,59	0,41	-0,22	-0,47						
Shin circumference (cm)	**8.**	-0,06	0,58	0,30	0,22	-0,19	-0,02	0,42					
arm circumference (cm)	**9.**	0,29	**0,86**	0,10	0,43	-0,09	0,24	0,66	**0,68**				
volume of chest - at inhalation (cm)	**10.**	0,29	**0,73**	0,31	0,29	0,17	0,25	0,24	**0,77**	**0,68**			
volume of the chest - at exhalation (cm)	**11.**	-0,03	0,54	0,08	0,44	-0,19	0,21	0,17	**0,73**	**0,68**	**0,80**		
chest breadth (cm)	**12.**	-0,06	0,34	-0,16	0,49	-0,08	0,25	0,17	0,49	0,52	0,50	**0,71**	
torso length (cm)	**13.**	-0,13	0,30	0,11	0,31	-0,53	-0,24	0,57	0,12	0,46	-0,08	-0,05	-0,34
	variable	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**

$p<0.05$ specified in bold.

On the basis of the carried out analysis of the slenderness of the body of the vaulters at the age of 17, 18 and 19 years old, referred to Rohrer index (which in comparison to previous studies of the author concerning the vaulters at a younger age showed its growth [15]), it was found that it reached up respectively the values of 1.15, 1.17 and 1.18 (see tab. 3). Similarly, increase in the indicator of shoulders was observed in the range from 72.95 (17-year-old) to 75.02 in athletes of 19 years' old age. While largest value of pelvis indicator for 18-year-old was 75.48.

Table 3

Average rate of body building of the vaulters.

No.	Types of indicators by Wanky	The studied age		
		17-year-old (n-11)	18-year-old (n-9)	19-year-old (n-9)
1.	Roher index	1.15	1.17	1.18
2.	Shoulder indicator,%	72.96	73.34	75.02
3.	Pelvis indicator	73.66	75.48	72.48

Analysis of the results of examined vaulters showed very high range of individual age groups' results, where standard deviation ranged from 44.38 (18-year-old) to 56.04 (17-year-old) (tab. 4). The largest difference between the

lowest and the best result in pole vault was in a group of 19-year-old vaulters (151 cm), and in this group one of the vaulters reached the best effect (551 cm).

Table 4

Result of pole vault of examined vaulters.

Efficiency tests	Statistical quantities	17 years old (n-11)	18 years old (n-9)	19 years old (n-9)
Pole vault result (cm)	M	398,64	407,78	463,60
	SD	56,04	44,38	52,89
	Min.	340,00	360,00	400,00
	Max	480,00	490,00	551,00

Table 5 shows the dependence of individual somatic features on the result of the pole vault. Statistically significant correlation of pole vault outcome takes place only between the volume of the chest – at exhale (/ 0.69 / of 19-year-old). There is interesting correlation between the height of the body (0.60) and the length of the lower limb (0.55) in group of 17-year-old vaulters. However, the highest quantity of correlations were with medium and low dependence.

Table 5

Analysis of somatic features of pole vault results (source, Klimczyk, 2012).

Lp.	Examined features	Pole vault result		
		17 years old	18 years old	19 years old
1.	Body height (cm)	0,60	0,33	0,15
2.	Body weight (kg)	0,13	0,37	0,33
3.	Shoulder width (cm)	-0,07	0,52	-0,20
4.	Pelvis width (cm)	0,04	0,17	0,43
5.	Lower limb length (cm)	0,55	0,52	0,02
6.	Upper limb length (cm)	0,26	0,41	0,40
7.	Thigh circumference (cm)	-0,07	0,13	-0,14
8.	Shank circumference (cm)	-0,12	-0,15	0,10
9.	Arm circumference (cm)	-0,40	-0,19	0,33
10.	Chest volume at inhale (cm)	0,19	0,59	0,44
11.	Chest volume at exhale (cm)	0,22	0,52	**0,69**
12.	Chest breadth (cm)	-0,35	0,17	0,47
13.	Torso length (cm	0,05	-0,31	-0,17

$p < 0.05$ in bold

Analysis of "Group A" somatic parameters (the vaulters, whose sport achievements are at leading positions in the world rankings) showed that this group has similar somatic conditions proved by dispersion of results around the standard deviation ranging from 0.9 (hip width) to 3.54 (volume of the chest at exhaling) (tab. 6). Average height and weight were respectively 191 cm and 82.3 kg (tab. 6). Difference between the extreme parameters of height and body weight of this group vaulters amounted to respectively 2 cm, 6 kg, while the widths of the shoulder and hips were respectively 4 cm and 2 cm. Other parameters are presented in table 6.

Table 6

The parameters of the somatic built of the vaulters.

Lp.	Examined parameters	Examined vaulters				Statistical quantities	
		L. M.	M.M.	D.E.	S.L.		
1	body height (cm)	190	192	192	190	M	191
						SD	1,15
						Min	190
						Max	192
2	body weight (kg)	85	79	83	82	M	82,3
						SD	2,5
						Min	79
						Max	85
3	shoulder width (cm)	40,6	36,8	40,8	38,8	M	39,26
						SD	1,86
						Min	36,8

						Max	40,8
4	pelvis width (cm)	24,8	24,9	26,5	24,5	M SD Min Max	25,2 0,9 24,5 26,5
5	lower limb length (cm)	96,7	96,4	99,4	99,8	M SD Min Max	98,1 1,77 96,4 99,8
6	upper limb length (cm)	83,3	83,8	87	85,2	M SD Min Max	84,8 1,66 83,3 87
7	thigh circumference (cm)	50,7	48	51	54	M SD Min Max	50,9 2,45 48 54
8	Shin circumference (cm)	40	37,5	36,5	36,7	M SD Min Max	37,6 1,61 36,5 40
9	arm circumference (cm)	32	30,7	33	36	M SD Min Max	32,9 2,26 30,7 36
10	volume of chest at inhale (cm)	109	102	105	109,5	M SD Min Max	106,4 3,54 102 109,5
11	volume of chest at exhale (cm)	98	95	97	100	M SD Min Max	97,5 2,08 95 100
12	chest breadth (cm)	11	7	8	9,5	M SD Min Max	8,9 1,75 7 11
13	torso length (cm)	50,8	53,1	52,4	49,8	M SD Min Max	51.5 1,5 49,8 53,1

Slenderness of the body established on the basis of Rohrer index showed that the greatest value has Ł.M. (1.24), while the lowest is for M.M. (1.12) (tab. 7). The average value of this index of the studied group is 1.18, while the average rate of the shoulders and the pelvis is respectively 76.25 and 64.2.

Table 7

Average rate of body building of the vaulters.

No.	Types of indicators by Wanky	Examined vaulters				Statistical quantities	
		L. M.	M.M.	D.E.	S.L.		
1.	Pointer Roher	1.24	1.12	1.17	1.19	M	1.18
2.	index shoulder, %	79.92	69.3	77.86	77.91	M	76.25
3.	indicator pelvis	61.08	67.66	64.95	63.14	M	64.2

The results of four vaulters' analysis showed the diversity of individual achievements (the standard deviation is 12.87). The best result belonged to D.E. 600 cm, and the lowest was by 29 cm lower (Ł.M.) (tab. 8).

Table 8

Pole vault results of "Group B" members.

No.	Performance test	Examined vaulters				Statistical quantities	
		Ł. M.	M.M.	D.E.	S.L.		
1	outcome of pole vault (cm)	571	580	600	575	M	581.5
						SD	12.87
						Min	571
						Max	600

Discussion

Interdependence of certain characteristics of somatic built with any parameter in determination of motor efficiency or with results of pole vault sets some differences, which took place in the studied group, as well as between certain vaulters. The researchers define this issue as rather complex one, eliminating the uniqueness of the individual dependence. [16]

By comparison, the height of body of the studied vaulters with the results of the studies of M. Napierała (2008), carried out in the area of the Kujawsko-Pomorskie Voivodeship, it appears that the studied vaulters at the age of 18 years are taller than their peers (M. Napierała: 18.5 years, 178,69cm). In addition, the comparison of body weight of the vaulters with the results of M. Napierała (2008), carried out in the area of the Kujawsko-Pomorskie Voivodeship, contributed to the finding that the studied vaulters have higher value of mean body weight. In the studies of M. Napierała (2008) it is as follows: M. Napierała 18.5 years 71.89 kg. It is interesting that height and weight of the vaulters obtaining the best results at the world level is very different, e.g. height of the body varies from 170 cm to 200 cm.

By comparing the results of the study of body slenderness, referred to Rohrer index of 17, 18, 19-year-old athletes, it can be noted that this index increases from the value of 1.15 (17-year-old) to 1.18 (19-year-old). The smooth growth of this index can occur under influence biological development period as well as under used training loads. It also affects growth of their muscle mass as well as width of hips, shoulders and volume parameters (e.g.: the circumference of thighs, drumsticks, arm). It is also associated with significantly slowed down increase of height of the body.

According to experts [5, 11], regularity in somatic built plays special role in terms of the efficiency of complex motor sequences (e.g., for pole vault), it is associated with their implementation, coordination and biomechanics of movement. The world's finest vaulters demonstrate this regularity.

Conclusions

- Analysis of the study results of the somatic built (17-19-year-old vaulters) showed large diversity, but much less it was seen in "Group A".
- "Group A" vaulters exceed 19-years'-old ones in average height and weight (up to 3.22 cm and 5.72 kg). In the widths of hips and shoulders the vaulters of 19 years' old age dominate. Other parameters, with the exception of the circumference of thighs, drumsticks and length of the torso, have higher values and belong to the vaulters of "Group A".
- "Group A" vaulters have better average results in pole vault (by 117.4 cm) than 19-years'-old vaulters.
- By comparing Rohrer index, indicating body slenderness of 17-18-19-year-old vaulters, fluent increase was noticed.
- The same average value of Rohrer index belonged to 19 years old vaulters and four vaulters of "Group A".
- Vaulters' group belonging to the "world's finest" was characterized by higher rate of shoulders than members of other studied groups.
- Vaulters of 17, 18 and 19 years old age have average score of pelvis higher than the Group of four vaulters (Ł.M., M.M., D.E., S.L.).
- It was found that results of pole vault indeed statistically correlate with only one sample (19-year-old vaulters /0.69/ - the volume of the chest, breathing out).
- Due to (inter alia) insufficient quantity of the studied persons the relationship between the somatic built and the result in the pole vault cannot be definitely stated.

There seems to be significant influence on sport technique and results in pole vault belonging to the proportions of the individual somatic features and here the relevant connections can be seen.

Conflict interests

The authors declare they have no conflict interests.

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