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SOMATIC DETERMINANTS OF SPORTS PERFORMANCE IN POLISH SPRINTERS

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Abstract:

Aim. The aim of this study was to identify the determinants of somatic build of athletes at different (national and club) levels of sports skills. Furthermore, the study attempted to establish relationships between the performance in the 100m and 200m sprints and the parameters studied in the groups of sprinters and a control group (university students).

Materials. The study included a selected group of sprinters (n=34). The sports skill level of the athletes was determined according to the track and field standards of the Polish Athletics Association (Polish: Polski Związek Lekkiej Atletyki, PZLA) as a sports class (Class I: national level, Class II: club level). The control group (n=62) consisted of sophomore full-time male students of physical education from the University of Physical Education in Krakow, Poland.

Results and Conclusions. The results indicated that there was little intergroup variation in somatic build for characteristics such as hip width, elbow width, arm circumference, and largest thigh circumference. A significant effect on the improvement in scores in Class I athletes was found for R skinfold (over ticeps skin-fold) in 100m sprinters and the sum of R+Ł skinfolds (over ticeps + subscapular skin-fold) in 200m sprinters. In other groups, associations with the 100m score were shown for shoulder width, lower limb length, B skinfold (on abdonmen skin-fold), Ł skinfold, R skinfold, hip width, whereas for 200m, this concerned the largest lower leg circumference and R skinfold.

Introduction

Sprints are considered to be relatively simple sporting events [1], even though a variety of factors influence the results [2-8].

As already noted above, an important role in short-distance running demonstrated by the results of many scientific investigations conducted by many researchers is performed by the parameters of the somatic build of sprinters and their association with sports performance. The functional status of muscle units also affects the ability to increase speed during distance running [6,9-14].

Sprinters competing in the 60m and 100m races are often characterized by a more massive physique than those who perform better in the 200m, which is generally strongly correlated with muscle strength [10].

A series of examinations of athletes of various sports showed that sprinters are characterized by a specific muscle structure. Based on biopsy, it was found that the proportion of fast-twitch fibers (FT) in this group of athletes is on average 67% (from 42 to 84%), while the average of the normal population is ca. 50% [5,11]. The research conducted in the groups of sprinters by Mero and Komii [12] also demonstrated that contrary to the athletes of other events, FTb fibers dominated among fast-twitch fibers (38% of all fibers) in the group studied.

The stride length and step frequency are also important aspects here as they affect the sprinting performance [15]. The same authors described sprinter Usain Bolt, who achieved the highest average stride length (2.83 m) and the lowest average step frequency (4.13 steps/s) compared to other athletes. Therefore, as the above authors argue, this situation is reflected in the body structure. It should be mentioned here that even before Usain Bolt appeared on the world's sports arenas, Kruczalak [2] showed that there was no significant relationship between sprinters' body height and their performance.

It is also worth mentioning that among former and current champions and world record holders in sprinting events, there are both tall sprinters (Usain Bolt – 196 cm, Asafa Powell – 190 cm, Carl Lewis – 188 cm, Donovan Bailey – 183 cm, Tayson Gay – 183 cm, and Christophe Lemaitre – 190 cm, who is called the fastest white sprinter in history and took this title away from Polish record holder Marian Woronin – 181cm) and those who are relatively short (Maurice Greene – 176 cm, Kim Collins – 175 cm, Andre Cason – 170 cm).

As can be seen from the above brief review of research on the effect of the characteristics of somatic build that determine high performance in athletic sprinting, these are issues that need to be further researched, clarified, and discussed extensively.

Therefore, it seems important to undertake research in this area for the adopted assumptions to verify and update the picture of contemporary Polish sprinters at different levels of sports skill and search for other determinants affecting the sports performance in sprint running.

The aim of this study was to identify the determinants of the somatic build of athletes at different (national and club) levels of sports skills. Furthermore, the study attempted to establish relationships between the performance in the 100m and 200m sprints and the parameters studied in the groups of sprinters and a control group (university students).

Research materials and methods

To answer the research problems presented in the study, a group of athletes (34 sprinters) was selected using purposive sampling. They were athletes from the Polish team champion club (AZS AWF Kraków Sports Club, see Tab. 1).

The sports skill level of the athletes was determined according to the track and field standards of the Polish Athletics Association (Polish: Polski Związek Lekkiej Atletyki PZLA) as a sports class (Class I: national level, Class II: club level).

In order to compare the material collected in the group of athletes, an identical study was conducted among sophomore university students (control group) of full-time studies of physical education at the Bronisław Czech University of Physical Education in Krakow, Poland (62 people), who did not practice short distance running at a competitive level (Tab. 1). All students practicing any sport in a regular and organized manner were excluded from the study.

All examinations were conducted during the annual macrocycle of track and field training. During this period, the athletes trained at the National Sports Center in Spala, Poland, and at the facilities of the University of Physical Education in Krakow.

All participants met the criterion of no medical contraindications. They gave their informed consent to participate in the experiments and were informed of all research procedures in accordance with the ethical principles of the Declaration of Helsinki WMADH (16). The study was approved by the Bioethics Committee No. 17/KBL/OIL/2012 at the Regional Medical Chamber in Kraków.

Table 1. Sports skill level, number, age, and training experience in sprinters and students from the University of Physical Education in Krakow

Sports skill level (Class)	Number of participants	Age		Training experience	
			S		S
Class I (I), national level	14	21.29	4.94	6.43	3.65
Class II (II), club level	20	17.65	2.39	3.20	1.24
AWF students (control group) – no sports class	62	20.37	0.68	--	--
TOTAL	**96**				

The scope of the study included measurements of the characteristics of somatic build: body height and weight, trunk and leg length, shoulder and hip width, thickness of triceps, abdominal, and subscapular skinfolds, ankle, knee, and elbow width, circumference, and amplitude of chest mobility, circumferences of the arm, neck, and hip, and the largest circumference of the forearm, lower leg, and thigh.

Methods

Anthropometric measurements were performed using a set of instruments commonly used in anthropometry, according to international standards, the definitions of characteristics, and using Rudolph Martin's measurement technique (anthropometer, spreading caliper, slide caliper, anthropometric tape, skinfold caliper, scale) [17-18].

Methods of material processing and statistical analysis

Anthropometric measurements allowed for the calculation of:

- height-to-weight ratio (slenderness index): body type was determined by the slenderness index (SI) expressed by the ratio of body height to body mass according to the formula by (Łaska-Mierzejewska 1980) $WS=BH/\sqrt[3]{BM}$, where: BH – means body height (in cm), BM – means body mass (in kg)
- lean body mass (LBM – Lean body mass), Based on the structural characteristics: body height, body mass, fatness (triceps skinfold over the triceps brachii, subscapular skinfold below the right inferior angle of the scapula, and abdominal skinfold in one-fourth of the distance between the navel and anterior superior iliac spine) and based on the regression equations proposed by Slaughter et al. (1988), the following values of lean body mass (LBM0) were calculated for each participant:
- Quetelet II Index (BMI-Body Mass Index), $BMI = BM/BH^2$, where BM Y means body mass (in kg), and BH is body height (in m).

To analyze the variables studied, basic statistical measures were computed such as arithmetic mean ($\overline{x}$), standard deviation (S), variability (V), asymmetry (As), and kurtosis (Ku).

A correlation vector was determined to evaluate the statistical significance for individual explanatory variables (X) relative to the response variables (100m and 200m). The analysis used above is a measure of the relationship between two variables. Therefore, issues such as the effect of sports training or biological development should be explained using multivariate analyses. An appropriate tool in this regard is multiple regression. The use of regression provides a description of the relationships that exist between the predictors and the response variable. Sports performance, expressed as a variable measured on a quotient scale, can also be a response variable.

The post-hoc Tukey multiple comparisons test was used to determine the statistical characteristics of the intergroup differences between the Class I/Class II sprinters and students.

The research material was processed using the STATISTICA software package ver. 8 (StatSoft®).

Results

Somatic build

Statistical characteristics of the intergroup differences between the Class I/Class II sprinters and students are shown in Table 2.

As can be seen from the data collected (Tab. 2), in the case of body height, the Class I athletes are characterized by the highest mean body height (180.38 cm, S±6.43), whereas the lowest mean body height was found for Class II sprinters (178.39 cm, S±4.77). The students surveyed had a mean body height of 179.33 cm (S±5.81).

Based on the statistical characteristics of the body mass of the sprinters studied (Tab. 2), the highest body mass was found in students (74.87 kg, S±7,98). Class II athletes had the lowest body mass (69.89 kg, S±5,10).

The mean BMI of Class I sprinters was 22.48 (S±1.82). In Class II sprinters, this index was 21.95 (S±1.12), whereas in students from the control group - 23.26 (S±1.95) (Table. 2). On the other hand, the mean LBM was 63.46 (S±6.92) in Class I sprinters, 59.84 (S±5.21) in Class II sprinters, and 63.49 (S±6.19) in the controls.

Statistical characteristics of lower limb length (Tab. 2) showed the longest lower limb in Class II athletes, with a mean length of 93.92 cm (S±2.76). Class I athletes had the shortest lower limbs (93.60 cm, S±3.86). In the control group of students, the mean lower limb length was 90.12 cm (S±4.23).

The mean hip width was 29.14 cm (S±1.61) in Class I sprinters, 31.41 cm (S±1.61) in Class II sprinters, and 28.23 cm (S±1.22) in the control group.

Statistical characterization of elbow width revealed the mean widest elbow in students (8.21 cm, S±0.51). The mean elbow width in Class I athletes was 7.85 cm (S±0.76). Class II athletes had the narrowest elbow, at a mean of 7.41 cm (S±0.55).

The R skinfold was 6.69 mm (S±1.12) in Class I sprinters, 7.87 mm (S±2.44) in Class II sprinters, and 8.06 mm (S±3.11) in students from the control group.

Furthermore, the mean Ł skinfold was 8.75 mm (S±1.33) in Class I sprinters 8.75 mm (S±1.73) in Class II sprinters, and 9.31 mm (S±2.57) in the controls.

The mean B skinfold measurements were 7.46 mm (S±1.26) in Class I sprinters, 7.67 mm (S±1.64) in the Class II group, and 10.40 mm (S±5.14) in the control group.

As can be seen from the data collected (Tab. The mean R+Ł+B skinfold in Class I sprinters was 22.90 mm (S±2.71). In Class I sprinters, this was 24.30 mm (S±5.17) and in students from the control group – 27.77 mm (S±9.04).

The mean R+Ł skinfold was 15.44 mm (S±1.90) in Class I sprinters, 16.62 mm (S±3.77) in Class II athletes, and 17.37 mm (S±4.87) in students from the control group.

Statistical characteristics of chest circumference (Table 2) showed the largest values in students, with

Table 2. Statistical characteristics of intergroup differences in somatic build in Class I and Class II sprinters and students based on post-hoc Tukey multiple comparisons test

Variable	Class 1		Class 2		Students	
	$\bar{x}$	S	$\bar{x}$	S	$\bar{x}$	S
Body height (cm)	180.38	6.43	178.39	4.77	179.33	5.81
Body mass (kg)	73.27	8.19	69.89	5.10	74.87	7.98
Slenderness index	43.17	1.21	43.33	0.83	42.62	1.26
BMI	22.48	1.82	21.95	1.12	23.26	1.95
LBM	63.46	6.92	**59.83****	5.20	63.49	6.14
Upper body length [cm]	146.95	4.71	143.99	4.68	146.66	5.05
Lower limb length (cm)	93.60	3.86	**93.92***	2.76	**90.12***	4.23
Shoulder width (cm)	41.75	2.98	38.82	2.60	42.72	2.12
Hip width (cm)	**29.14**##**	1.61	**31.41## ^ ^**	1.61	**28.23 ^ ^**	1.22
Ankle width (cm)	7.20	0.47	7.27	0.34	7.47	0.39
Knee width (cm)	10.01	0.64	9.87	0.46	10.09	0.48
Elbow width (cm)	7.85	0.76	**7.41**##**	0.55	**8.21##**	0.51
R skinfold (mm)	6.69	1.12	7.87	2.44	**8.06***	3.11
Ł skinfold (mm)	8.75	1.33	8.75	1.73	9.31	2.57
B skinfold (mm)	7.46	1.26	7.67	1.64	**10.40***	5.14
Sum of R+Ł+B skinfolds (mm)	22.90	2.71	24.30	5.17	27.77**	9.04
Sum of R+Ł skinfolds (mm)	15.44	1.90	16.62	3.77	17.37*	4.87
Chest circumference (cm)	87.38	3.74	84.87	2.81	87.93	4.16
Chest amplitude (cm)	93.18	4.18	**90.72***	3.03	**94.65***	4.30
Exhalation chest amplitude (cm)	86.12	4.16	**82.74##**	2.75	**87.77*##**	4.03
Largest forearm circumference (cm)	27.55	1.49	**26.07***	1.47	**27.64***	1.99
Arm circumference (cm)	**30.06#**	1.78	**27.755*# ^ ^**	1.71	**30.60 ^ ^**	2.69
Largest lower leg circumference (cm)	37.89	3.27	37.57	1.67	37.31	2.38
Largest thigh circumference (cm)	**55.09***	4.12	**54.68##**	1.59	**55.48 ^**	2.99
Hip circumference (cm)	93.80	3.80	**93.17***	2.44	**96.88***	4.79
Neck circumference (cm)	38.53	2.20	38.77	1.15	38.23	1.31

Abbreviations: *, #, ^ , + statistically significant differences at $p \leq 0.05$,
**, ##, ^ ^ ,++ statistically significant differences at $p \leq 0.01$

mean values of 87.93 cm (S±4.16). Class I sprinters had slightly smaller chest circumference (87.38 cm, S±3.74). Class II athletes had the smallest chest circumference, at a mean of 84.87 cm (S±2.81).

The chest amplitude was 93.18 cm (S±4.18) in Class I sprinters, 90.72 cm (S±3.03) in Class II athletes, and 94.65 cm (S±4.30) in students from the control group.

The mean exhalation chest amplitude was 86.12 cm (S±4.16) in Class I sprinters, 82.74 cm (S±2.75) in Class II athletes, and 87.77 cm (S±4.03) in students from the control group.

The largest forearm circumference was 27.55 cm (S±1.49) in Class I sprinters, 26.07 cm (S±1.47) in Class II athletes, and 27.64 cm (S±1.99) in students from the control group.

The largest arm circumference was found in students, with mean values of 30.60 cm (S±2.69). Class I sprinters had slightly smaller arm circumference (30.06 cm, S±1.78). Class II athletes had the smallest arm circumference, at a mean of 27.75 cm (S±1.71).

The largest lower leg circumference was 37.89 cm (S±3.27) in Class I sprinters, followed by 37.57 cm (S±1.67) in Class II athletes, and 37.31 cm (S±2.38) in students from the control group.

The mean largest thigh circumference was 55.09 cm (S±4.12) in Class I athletes, 54.68 cm (S±1.59) in the Class II group, and 55.48 cm (S±2.99) in the control group.

The largest hip circumference was found in students, with mean values of 96.88 cm (S±4.79). The mean hip circumference in Class I athletes was 93.80 cm (S±3.80). Class II athletes had the smallest hip circumference, at a mean of 93.17 cm (S±2.44).

The mean neck circumference was 38.53 cm (S±2.20) in Class I athletes, 38.77 cm (S±1.15) in the Class II group, and 38.23 cm (S±1.31) in the control group.

For body height parameter (Tab. 3), no statistically significant differences were found.

For body mass parameter (Tab. 4), there were no statistically significant differences between Class I/Class II athletes and students.

Table 3. Statistical characteristics of post-hoc Tukey test for the variable of body height in the groups studied

Group	**HSD (uneven N); variable: Body height (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=180.38	Class II athletes M=178.39	Students M=179.33
Class I athletes		0.844078	0.636485
Class II athletes	0.844078		0.082987
Students	0.636485	0.082987	

Table 4. Statistical characteristics of post-hoc Tukey test for the variable of body mass in the groups studied

Group	**HSD (uneven N); variable: Body mass (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=73.27	Class II athletes M=69.89	Students M=74.87
Class I athletes		0.845078	0.636485
Class II athletes	0.845078		0.082999
Students	0.636485	0.082999	

Table 5. Statistical characteristics of post-hoc Tukey test for the variable of body mass index (BMI) in the groups studied

Group	**HSD (uneven N); variable: BMI (Body Mass Index) (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=22.485	Class II athletes M=21.948	Students M=23.260
Class I athletes		0.844078	0.636485
Class II athletes	0.844078		0.082987
Students	0.636485	0.082987	

For the parameter of BMI (Tab. 5), no statistically significant differences were found.

For the LBM parameter (Tab. 6), there were no statistically significant differences between the groups studied.

For the parameter of lower limb length (Tab. 7), statistically significant differences were observed between the lower limb length in Class II athletes and students (p=0.02). No statistically significant differences were found for other interactions.

For the hip width parameter (Tab. 8), statistically significant differences were found between Class I and class II athletes (p=0.0002). Statistically significant differences were also found for hip width between Class II athletes and students (p=0.0001). No statistically significant differences were found for other interactions.

For the elbow width parameter (Tab. 9), statistically significant differences were observed between Class II and non-athletes (p=0.0001). No statistically significant differences were found for other interactions.

Table 6. Statistical characteristics of post-hoc Tukey test for the variable of LBM in the groups studied

Group	**HSD (uneven N); variable: LBM (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=63.460	Class II athletes M=59.839	Students M=63.495
Class I athletes		0.373543	0.999999
Class II athletes	0.373543		0.213315
Students	0.999999	0.213315	

Table 7. Statistical characteristics of post-hoc Tukey test for the variable of lower limb length in the groups studied

Group	**HSD (uneven N); variable: Lower limb length (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=93.600	Class II athletes M=93.925	Students M=90.123
Class I athletes		0.996981	0.129476
Class II athletes	0.996981		**0.024680**
Students	0.129476	**0.024680**	

Table 8. Statistical characteristics of post-hoc Tukey test for the variable of hip width in the groups studied

Group	**HSD (uneven N); variable: Hip width (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=29.136	Class II athletes M=31.411	Students M=28.227
Class I athletes		**0.000260**	0.295913
Class II athletes	**0.000260**		**0.000138**
Students	0.295913	**0.000138**	

Table 9. Statistical characteristics of post-hoc Tukey test for the variable of elbow width in the groups studied

Group	**HSD (uneven N); variable: Elbow width (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=7.8500	Class II athletes M=7.4100	Students M=8.2129
Class I athletes		0.158293	0.310516
Class II athletes	0.158293		**0.000199**
Students	0.310516	**0.000199**	

Table 10. Statistical characteristics of post-hoc Tukey test for the variable of R skinfold in the groups studied

Group	HSD (uneven N); variable: R skinfold (Vector) Marked differences are significant at $p < .05000$		
	Class I athletes M=6.6929	Class II athletes M=7.8700	Students M=8.0565
Class I athletes		0.639051	0.520783
Class II athletes	0.639051		0.996084
Students	0.520783	0.996084	

Table 11. Statistical characteristics of post-hoc Tukey test for the variable of Ł skinfold in the groups studied

Group	**HSD (uneven N); variable: Ł skinfold (Vector) Marked differences are significant at $p < .05000$**		
	Class I athletes M=8.75	Class II athletes M=8.75	Students M=9.31
Class I athletes		0.844078	0.536485
Class II athletes	0.844078		0.082787
Students	0.536485	0.082787	

Table 12. Statistical characteristics of post-hoc Tukey test for the variable of B skinfold in the groups studied

Group	**HSD (uneven N); variable: B skinfold (Vector) Marked differences are significant at $p < .05000$**		
	Class I athletes M=7.4571	Class II athletes M=7.6750	Students M=10.403
Class I athletes		0.998962	0.203787
Class II athletes	0.998962		0.133634
Students	0.203787	0.133634	

Table 13. Statistical characteristics of post-hoc Tukey test for the variable of the sum of R+Ł+B skinfolds in the groups studied

Group	**HSD (uneven N); variable: Sum of R+Ł+B skinfolds (Vector) Marked differences are significant at $p < .05000$**		
	Class I athletes M=22.900	Class II athletes M=24.300	Students M=27.773
Class I athletes		0.956558	0.290583
Class II athletes	0.956558		0.433516
Students	0.290583	0.433516	

For the R skinfold parameter (Tab. 10), there were no statistically significant differences.

For the Ł skinfold parameter (Tab. 11), there were no statistically significant differences between the athletes studied at each sports skill level and the students.

For the B skinfold parameter (Tab. 12), there were no statistically significant differences.

For the parameter of the sum of R+Ł+B skinfolds (Tab. 13), there were no statistically significant differences.

For the parameter of the sum of R+Ł skinfolds (Tab. 14), there were no statistically significant differences.

For the parameter of chest circumference (Table 15), there were no statistically significant differences between Class I/Class II athletes and students.

For the parameter of chest amplitude (Tab. 16), statistically significant differences were observed only when comparing the index for Class II athletes and students ($p=0.01$). No statistically significant differences were found for other interactions.

Table 14. Statistical characteristics of post-hoc Tukey test for the variable of the sum of R+Ł skinfolds in the groups studied

Group	HSD (uneven N); variable: Sum of R+Ł skinfolds (Vector) Marked differences are significant at p < .05000		
	Class I athletes M=15.443	Class II athletes M=16.625	Students M=17.369
Class I athletes		0.872943	0.605563
Class II athletes	0.872943		0.940661
Students	0.605563	0.940661	

Table 15. Statistical characteristics of post-hoc Tukey test for the variable of chest circumference in the groups studied

Group	**HSD (uneven N); variable: Chest circumference (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=87.386	Class II athletes M=84.870	Students M=87.935
Class I athletes		0.309517	0.981335
Class II athletes	0.309517		0.060866
Students	0.981335	0.060866	

Table 16. Statistical characteristics of post-hoc Tukey test for the variable of chest amplitude in the groups studied

Group	**HSD (uneven N); variable: Chest amplitude (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=93.179	Class II athletes M=90.720	Students M=94.653
Class I athletes		0.374840	0.767715
Class II athletes	0.374840		**0.013568**
Students	0.767715	**0.013568**	

Table 17. Statistical characteristics of post-hoc Tukey test for the variable of exhalation chest amplitude in the groups studied

Group	**HSD (uneven N); variable: Exhalation chest amplitude (Vector) Marked differences are significant at p < .05000**		
	Class I athletes M=86.121	Class II athletes M=82.740	Students M=87.774
Class I athletes		0.098330	0.667428
Class II athletes	0.098330		**0.000509**
Students	0.667428	**0.000509**	

For the parameter of exhalation chest amplitude (Tab. 17), statistically significant differences were observed between the index for Class II athletes and students (p=0.0005). No statistically significant differences were found for other interactions.

For the parameter of largest forearm circumference (Table 18), statistically significant differences were shown only between Class II athletes and students (p=0.02). No statistically significant differences were found for other comparisons.

For the arm circumference parameter (Tab. 19), statistically significant differences were observed for the index between Class I and Class II athletes (p=0.04). A statistically significant difference was also observed for comparison between the index for Class II athletes and students (p=0.0008).

For the parameter of largest lower leg circumference (Table 20), there were no statistically significant differences between Class I/Class II athletes and students.

Table 18. Statistical characteristics of post-hoc Tukey test for the variable of largest forearm circumference in the groups studied

Group	HSD (uneven N); variable: Largest forearm circumference (Vector) Marked differences are significant at p < .05000		
	Class I athletes M=27.550	Class II athletes M=26.070	Students M=27.645
Class I athletes		0.113499	0.998975
Class II athletes	0.113499		**0.024621**
Students	0.998975	**0.024621**	

Table 19. Statistical characteristics of post-hoc Tukey test for the variable of arm circumference in the groups studied

Group	HSD (uneven N); variable: Arm circumference (Vector) Marked differences are significant at p < .05000		
	Class I athletes M=30.064	Class II athletes M=27.755	Students M=30.605
Class I athletes		**0.040987**	0.922558
Class II athletes	**0.040987**		**0.000859**
Students	0.922558	**0.000859**	

Table 20. Statistical characteristics of post-hoc Tukey test for the variable of largest lower leg circumference in the groups studied

Group	HSD (uneven N); variable: Largest lower leg circumference (Vector) Marked differences are significant at p < .05000		
	Class I athletes M=37.893	Class II athletes M=37.575	Students M=37.306
Class I athletes		0.983204	0.906256
Class II athletes	0.983204		0.982722
Students	0.906256	0.982722	

Table 21. Statistical characteristics of post-hoc Tukey test for the variable of largest thigh circumference in the groups studied

Group	HSD (uneven N); variable: Largest thigh circumference (Vector) Marked differences are significant at p < .05000		
	Class I athletes M=55.086	Class II athletes M=54.680	Students M=55.476
Class I athletes		0.982511	0.984396
Class II athletes	0.982511		**0.820157**
Students	0.984396	**0.820157**	

For the largest thigh circumference parameter (Tab. 21), statistically significant differences were observed between Class II athletes and students (p=0.002). No statistically significant differences were found for other interactions.

For the hip circumference parameter (Tab. 22), statistically significant differences were found only between the values of the index for Class II athletes and students (p=0.02). No statistically significant differences were found in the case of other interactions.

For the neck circumference parameter (Tab. 23), there were no statistically significant differences between Class I/Class II athletes and students.

Characterization of the relationships between the results in the 100m and 200m runs and the parameters studied in the groups of sprinters and students

A correlation matrix was calculated to determine the relationships between the variables studied. In light of the research problem addressed in the present study, it was

Table 22. Statistical characteristics of post-hoc Tukey test for the variable of hip circumference in the groups studied

Group	HSD (uneven N); variable: Hip circumference (Vector) Marked differences are significant at $p < .05000$		
	Class I athletes M=93.800	Class II athletes M=93.170	Students M=96.879
Class I athletes		0.976328	0.189175
Class II athletes	0.976328		**0.023136**
Students	0.189175	**0.023136**	

Table 23. Statistical characteristics of post-hoc Tukey test for the variable of neck circumference in the groups studied

Group	HSD (uneven N); variable: Neck circumference (Vector) Marked differences are significant at $p < .05000$		
	Class I athletes M=38.529	Class II athletes M=38.770	Students M=38.234
Class I athletes		0.973305	0.953043
Class II athletes	0.973305		0.665307
Students	0.953043	0.665307	

extremely important to present the relationships between the response variables (100m and 200m) and the independent variables (x_1 - x_{62}).

In the group of Class II athletes, mean correlations between the variables and the result of the 100m run were found for parameters such as shoulder width, lower limb length, B skinfold, Ł skinfold, R skinfold, and hip skinfold.

In the group of non-athlete students, the correlations (weak correlations), between the variables and the result of 100m run were found for the hip width.

In the same comparison group, weak correlations between the variables and the result of the 200m run were also shown for hip width.

Based on the calculated coefficients of the regression equation, a significant effect on the improvement of the response variable - 100m in Class I athletes was demonstrated for parameters such as R skinfold, whereas the improvement in the response variable 200m in Class I athletes was affected by the sum of R+Ł skinfolds.

Significant effects on the improvement of the response variable 200m in Class II sprinters were observed for such parameters as largest lower leg circumference and R skinfold.

Summary

The present study analyzed the parameters of body composition and physique of athletes. Somatic build is one of the most important factors that affect the potential capabilities of an athlete in many sports [19-21]. In training strategies, somatic parameters such as body height and body mass determine the choice of technique, fighting tactics, or specialization in a given sporting event [22-23].

Our study found no statistically significant intergroup differences for body height and body mass of the participants. The body height of the athletes ranged from 178.39 to 180.37 cm, while body mass in all the groups studied was similar (69.89-75.15 kg).

Ozimek [24], based on his own research, found that athletes, including those involved in track and field, rowing, shooting, and team games, are characterized by greater body height and body mass compared to non-athletes. A similar analysis was performed by Zielic-zienok et al. [25], who investigated the somatic build characteristics of the leading sprinters of the 1990s and determined the mean values and ranges of body height and body mass (Tab. 24, 25) which they believed coaches should follow when recruiting and selecting athletes for specific sporting events.

These authors analyzed the above parameters of the world elite sprinters and also came to the conclusion that regardless of the athletes' sports skill level, the values of somatic characteristics are similar [25].

Similarly, a study [25] aimed, among other things, to determine the relationships between body composition and performance in short distance running, no significant relationship was found between the sports performance of the sprinters studied and body height and mass. A similar analysis was performed by Chmura et al. [15], who studied the levels of basic somatic parameters of the best sprinters of recent years. Their research has confirmed the opinion that the champion model in

Table 24. Indices of somatic characteristics recommended for recruitment for sprinting events according to Zieliczienok et al. [25]

Event	Body height (cm)	Body mass (kg)
100, 200m	175 – 180	65 – 70
400m	178 – 183	66 – 71

Table 25. Indices of somatic characteristics of sprinters at different sports skill levels according to Zieliczienok et al. [25]

Parameters	Athlete's sports skill level		
	Class I athlete (I)	Master class (M)	World elite sprinters
Race time, 100m (s)	10.60 - 11.0	10.30 - 10.60	10.18 and faster
Body height (cm)	179.2±1.01	179.8 ± 0.86	181.1 ± 0.98
Body mass (kg)	72.7±0.96	75.7 ± 1.37	77.1 ± 1.18

sprinting, as observed and recognized by coaches, is constantly changing and it can be said that these changes occur with the supremacy of a given sprinter in international arenas.

Similar to the above body composition parameters, our study found no major intergroup differences for slenderness index and BMI that characterize body build type. The value of the slenderness index ranged from 42.62 to 43.33, while for BMI, it ranged from 21.94 to 23.26. There were also no statistically significant intergroup differences. Slightly higher values were noted only in the control group of students; however, according to Stanula [26], high body mass (and consequently high muscle mass) in sports and events such as sprint running, weight lifting, shot put, javelin, and discus throwing, and in various combat sports does not result from obesity but a high sports skill level and a desirable effect of training work.

A large body of research has been published on the issues of somatic build in the aspect of the selection indices in various sports [27]. Body mass index (BMI) is one of the simplest to determine but not easy to interpret in sports [28]. In fact, BMI is a parameter often described in studies dealing with the problems of overweight and obesity. Therefore, in the case of athletes at an elite level, this approach to the evaluation of body composition may be misleading [29]. However, the usefulness of BMI in assessing the physique of athletes has been emphasized in several publications, providing many interesting data concerning athletes of various sports [30-32]. Furthermore, Tatarczuk et al. [33], who conducted a number of examinations on female university students, found that the effect of body height on selected motor skills is negligible, while body mass and BMI are more powerful in determining the level of selected motor parameters.

In our study, we noted in some cases a significant effect of parameters characterizing body composition on sports performance (such as largest lower leg circumference, R skinfold, and the sum of R+Ł skinfolds). Such relationships were also demonstrated by Suslov et al. [34] and Sozański et al. [35], who found that the maximum speed is not necessarily strictly related to the body type expressed in absolute terms. These determinants are forced by the very characteristics of sports competition. Therefore, the best speed performance is observed in individuals with varying body size characteristics, which should also be taken into account during the recruitment and selection of athletes.

According to Tatarczuk et al. [33] lean body mass (LBM) shows a correlation with motor skills, mainly regarding explosive strength of the lower limbs. Body fat percentage is strongly correlated with some manifestations of speed and strength abilities. Particularly significant relationships were found by Tatarczuk et al. [33] for lower limb strength measured by long jump, agility measured with the envelope run, and endurance measured by the number of kicks back to the front support position. These authors found no significant correlation of body fat with other motor skills. Therefore, according to Tatarczuk et al. [33], the amount of adipose tissue has a negative effect on the results obtained during activities that require speed and strength.

Furthermore, in a study by Paruzel et al. [36-37], the authors proved that there is quite a large variation in the correlation coefficients of somatic build, motor skills, and step frequency, which are components of running time. The differences were more pronounced between age groups, which may be, according to these authors, determined by biological development, increase in muscle and bone strength, improvement of body systems, and movement experience acquired with age.

Furthermore, Morin et al. [38] found that there were no significant relationships between BMI values, lower limb length, and other anthropological measurements. Although some correlations obviously exist, they are not enough to be considered in terms of determinants of sprinting performance.

In contrast, when examining the relationships of motor fitness levels, Tatarczuk et al. [33] found that body height, body mass, and body fat percentage have a negative effect on the outcomes obtained in agility, long jump, and endurance tests. In a previous study, Kruczalak [10] came to a slightly different conclusion that a higher sports skill level is achieved by individuals with a more massive build and less slender body.

Conclusions

1. The level of development of the somatic characteristics in the examined Polish sprinters reflects to a large extent the state needed to achieve a champion level in both sports classes (Class I and Class II athletes) as determined by the classification standards for Polish sprinters (Polish Athletics Association).
2. In the vast majority (almost 80%) of the characteristics and abilities, the group of non-athletes (students) deviated statistically significantly from the sprinters studied.
3. There was little intergroup variation regarding somatic build in the characteristics such as hip width, elbow width, arm circumference, and largest thigh circumference.
4. A significant relationship with the improvement in the response variable of 100m in Class I athletes was found for R skinfold, whereas the improvement of the response variable of 200m in this group was correlated with the sum of R+Ł skinfolds.
5. In the group of Class II athletes, mean correlations between the variables and the result of the 100m run were found for parameters such as shoulder width, lower limb length, B skinfold, Ł skinfold, R skinfold, hip width, whereas for 200m, this concerned largest lower leg circumference, and R skinfold.

References:

[1] Sozański H: *Podstawy teorii treningu sportowego*. Warszawa: Biblioteka Trenera. Centralny Ośrodek Sportu; 1999.

[2] Kruczalak E: *Teoretyczne i metodyczne podstawy treningu sportowego w lekkoatletycznych biegach krótkich*. Kraków: Akademia Wychowania Fizycznego Kraków, 1999. (Studia i Monografie, nr 5).

[3] Gabryś T: *Wydolność beztlenowa sportowców. Trening, kontrola, wspomaganie*. Katowice: AWF Katowice; 2000, p. 320.

[4] Milerova V, Hlina J, Kaplan A, Korbel V: *Behy na kratke trate. Trenink disiplin*. Praha: Olympia; 2001.

[5] Iskra J, Osik T, Walaszczyk A: *Trening w biegach sprinterskich dla początkujących i zaawansowanych.* Poznań: ARF Media Poznań; 2002.

[6] Maćkała K, Kowalski P: *Trening biegów krótkich. Założenia teoretyczne i implikacje praktyczne.* Wrocław: AWF Wrocław; 2007.

[7] Maćkała K, Cych P: *Charakterystyka czynników wpływających na czas reakcji w nauczaniu i doskonaleniu startu niskiego.* Wrocław: AWF Wrocław; 2011. (Rozprawy Naukowe, nr 33).

[8] Thompson PJL: *Podstawy treningu lekkoatletycznego. Oficjalny przewodnik IAAF dla trenerów*. Warszawa: Międzynarodowe Stowarzyszenie Federacji Lekkoatletycznych (IAAF), PZLA, MSiT; 2014.

[9] Viitasalo J, Komi P: *Force-time characteristics and fiber composition in human leg extensor muscles.* Eur. J. Appl. Physiol. Occup. Physiol. 1978;40(1):7-15.

[10] Kruczalak E: *Czynniki warunkujące poziom wyników sportowych w biegach na 100 i 200m oraz model szkolenia biegaczy na krótkie dystanse.* Kraków: AWF Kraków; 1979. (Studia i Monografie, nr 14).

[11] Radford P: *The nature and nature of a sprinter.* The Scientist. 1984;8:44.

[12] Mero A, Komi P.V: *Electromyographic activity in sprinting at different speeds ranging from submaximal to supramaximal.* Medicine and Science in Sports Exercises. 1987;3:226–274.

[13] Kraaijenhof H: *Trends in biomechanics and biochemistry of sprints methodology*. Track and Field quarterly Review. 1990;1:6–9.

[14] Chaffin DB, Andersson, GBJ: *Occupational Biomechanical Models. In: Occupational Biomechanics.* New York: Wiley; 1991.

[15] Chmura J, Chmura P, Ciastoń J: *Zdolności szybkościowe sprinterów.* Sport Wyczynowy. 2009;4(532):220-231.

[16] WMADH: *World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects*. Journal of the American Medical Association. 2000;20:3043-3045.

[17] Martin R: *Lehrbuch der Antropologie*. Jena; 1928.

[18] Drozdowski Z: *Antropometria w wychowaniu fizycznym*. Poznań: AWF Poznań; 1998, p. 24.

[19] Mermier CM, Janot JM, Parker DL, Swan JG: *Physiological and anthropometric determinants of sport climbing performance.* British Journal of Sports Medicine. 2000; 34(5):359–365.

[20] Gualdi-Russo E, Zaccagni L: *Somatotype, role and performance in elite volleyball players.* The Journal of Sports Medicine and Physical Fitness. 2001;41(2):256–262.

[21] Chaouachi A, Brughelli M, Levin G, Boudhina N.B.B, Cronin J, Chamari K: *Anthropometric, physiological and performance characteristics of elite team-handball players.* Journal of Sports Sciences. 2009;27(2):151–157.

[22] Bayios IA, Bergeles NK, Apostolidis NG, Noutsos KS, Koskolou MD: *Anthropometric, body composition and somatotype differences of Greek elite female basketball, volleyball and handball players*. The Journal of Sports Medicine and Physical Fitness. 2006;46(2):271–280.
[23] Gabbett T, Georgieff B: *Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players*. Journal of Strength and Conditioning Research. 2007;21(3):902–908.
[24] Ozimek M: *Determinanty wieloletniego przygotowania zawodników wysokiej klasy w wybranych dyscyplinach sportu.* Kraków: AWF Kraków; 2007. (Studia i Monografie, nr 45, p. 321).
[25] Zieliczienok WB, Nikituszkin WG, Guba WP: *Liegkaja atlietika: Kriterii Otbora.* Moskwa: Tierra Sporta; 2000.
[26] Stanula A: *Związki wybranych wskaźników kontroli wysiłkowej z efektami treningu sprinterek biegaczek* [Praca doktorska]. Katowice: AWF Katowice; 2003.
[27] De Koning JJ, Bakker FC, De Groot G, Van Ingen Schenau GJ: *Longitudinal development of young talented speed skaters: physiological and anthropometric aspects.* Journal of Applied Physiology. 1994;77(5):2311–2317.
[28] Eknoyan G: *Adolphe Quetelet (1796-1874) - the average man and indices of obesity. Nephrology, Dialysis, Transplantation: Official Publication of the European Dialysis and Transplant Association.* European Renal Association. 2008;23(1):47–51.
[29] Mitchell JA, Rodriguez D, Schmitz KH, Audrain-McGovern J: *Greater screen time is associated with adolescent obesity: a longitudinal study of the BMI distribution from Ages 14 to 18.* Obesity. 2013;21(3):572–575.
[30] Wilmore JH: *Body composition in sport and exercise: directions for future research.* Medicine and Science in Sports and Exercise. 1983;15(1):21–31.
[31] Čepulėnas A: *Interaction peculiarities of age somatic indices and sport results of ski-racers, participants of Olympic Winter Games.* Biology of Sport. 2006;23(1): 55-72.
[32] Knechtle B, Rüst CA, Rosemann T, Knechtle P, Bescos R: *Estimation bias: body mass and body height in endurance athletes.* Perceptual and Motor Skills. 2012;115(3):833–844.
[33] Tatarczuk J, Asienkiewicz R, Wandycz A: *Współzależność pomiędzy wybranymi parametrami somatycznymi* i *zdolnościami motorycznymi wśród studentek Uniwersytetu Zielonogórskiego.* Poznań: WSPiA w Poznaniu; 2007. (Zeszyty Naukowe WSPiA w Poznaniu, nr 3).
[34] Susłow FP, Sycz WL, Szustin BN: *Sowremiennaja sistema sportiwnoj podgotowki*. Moskwa: SAAM; 1995.
[35] Sozański H, Witczak T, Starzyński T: *Podstawy treningu szybkości*. Warszawa: Centralny Ośrodek Sportu; 1999.
[36] Paruzel M, Walaszczyk A, Iskra J: *Elite male and female sprinters' body build, stride length and frequency.* Studies in Physical Culture and Tourism. 2006;1:33–37.
[37] Paruzel–Dyja M, Iskra J, Skowronek T, Walaszczyk A: *Stride length and frequency and the velocity of a sprint race in groups of various age and sport level*. Movement and Health. 2006. p. 313- 320.
[38] Morin J, Bourdin M, Edouard P, Peyrot N, Samozino P, Lacour J: *Mechanical determinants of 100-m sprint running performance.* European Journal of Applied Physiology. 2012;112(11):3921-30.

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