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CHARACTER OF RELATIONSHIP BETWEEN SOMATIC COEFFICIENTS AND PHYSIOLOGICAL PARAMETERS THE 15-17 YEAR OLD ICE-HOCKEY PLAYERS

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Abstract. *The somatic structure in the significant degree determines the possibilities of applying definite tactical solutions, he can limit or stimulate unreeling the competitor individual technique. Somatic conditions can be the limiter of the motor preparation and coordination. The aim of investigations was qualification of dependence between coefficients of the somatic parameters and coefficients of aerobic and anaerobic efficiency. In investigations participated hockey players of National Team Poland in the age from 15 to 17 years. Essential dependences stepped out between the coefficients of aerobic and anaerobic efficiency, and the coefficients of the somatic conditions counted from the value of mass and the length of the body. The number of appointed dependences is higher in hockey players team U18 in the comparison with hockey players team U15.*
Keywords: *ice hockey, physiological parameters, somatic coefficients.*

Introduction

The somatic build of the ice hockey player, is considered one of the key factors conditioning the possibility of achieving high sports results in this discipline (Argeet et al.,1988; Quinney et al., 2008). Body length, and body mass are basic somatic factors of the ice hockey player, on the basis of which, comparative analyses are done on different sports levels (Allisse et al., 2017; Farlinger et al., 2007; Stanula et al., 2013). Competing, in ice hockey, which allows body play, requires a somatic build enabling competition against the opponent on equal terms. It is, thus, the fourth area, besides physical, technical, and tactical preparation, which cannot be omittedwhile evaluating the

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competitor's sports perspectives. The somatic build determines, to a great extent, the possibilities of applying specific tactical solutions, it can either limit, or stimulate the development of a competitor's individual technique (Kutac & Sigmund, 2015). Off course, the somatic conditions cannot be the limiting factor of motoric, and coordination preparation. As in all sports disciplines, the right ratio between body length, body mass, and the tasks to be performed on the ice rink, determine start efficiency, and the prospects of a hockey player's professional development (Neary et al., 2003; Sherar et al., 2007). Numerous studies show relationships between physiological indexes, and the somatic build of the competitors in various sports disciplines (Chaouachi et al., 2009; Duncan et al., 2006). In ice hockey, both the aerobic, and the anaerobic capacity, are equally important in the motoric preparation of the athlete (Green et al., 2006; Vescovi et al., 2006). The changes in physiological indexes, are also related to the changes in the somatic build in the biological development period (Brtkova et al., 2014). Both, the training, and the natural biological development, are natural stimulants of the development of every young athlete, including the ice hockey player (Aitken & Jenkins, 1998; Gil et al., 2007a, 2007b; Gröger et al., 2001). The aim of this study, was to determine the nature of the relationship between the values of physiological aerobic, and anaerobic capacity indexes, and the somatic build indexes of the Polish National Team ice hockey players aged 14-17 years old.

Material and methods

The study group included Polish National Team ice hockey players aged 15-17 years old. The group of 15 year old hockey players (U-16) included 20 competitors. Body height: 177.33 ± 4.16 cm, body mass: 70.54 ± 7.6 kg. The group of 17 -year -olds (U-18) can be characterized as follows: body height: 179.48 ± 4.85 cm, body mass: 77.16 ± 9.27 kg.

The level of aerobic capacity was evaluated on the basis of a progressive test carried out by means of a cycloergometer Cyclus 2 (RGB, Germany), according to the following program: the three first levels in two minutes carried out with the power of 0.75, 1.5, 2.5 W/kg of body mass, the next levels: 1 minute with an increase in power by 0.5W/kg. With the aid of a K4b2 analyzer (Cosmed, Italy), the following values were registered by means of a breath-by-breath system: VO2, VCO2, VE, RF, and HR .

The Polar Team2 system (Polar OY Finland) was used for this purpose. Anthropometric measurements done according to the "Anthropometric standardization reference manual" (Lohman et al., 1988), constituted part 1 of the study. (Tab. 1) Aerobic capacity evaluation: the participant carried out the effort until refusal to go on. The first three effort levels, whose work time was 2 minutes, were characterized by subsequent loads amounting to: 1.5, 2.25, and 3 W/kg, whereas the next ones were 1 minute long, and the increase in power was as follows: 3.5, 4, 4.5, and then by a further 0.5 W/kg of body mass of the participant.

During the effort trial, parameters such as: maximum oxygen usage- VO_{2max} (l/min), maximum ventilation - VE_{max} (l/min), and heart systole frequency - HR (bp/min). Anaerobic capacity evaluation. The participant carried out the Wingate test. The trial consisted in carrying out a 30-second maximum effort, on a cycloergometer with an 8 % (U-16), and a 9 % (U-18) body mass load, on a Cyclus-2 cycle ergometer. Once the rotation frequency of 100 rot./min. was attained, the load turned on. The registered parameters were: the maximum power - P_{max} (W),the total work - W_{tot} (J), and the power fall index (IF). The evaluation of anaerobic capacity was carried out using the cycloergometric test (Roczniok et al., 2016) on a Cyslus 2 Ergometer (RBG, Germany), registering power, work, and the tiredness coefficient, expressed by the amount of a decrease in power during effort.

Table 1 **Indicators of the somatic structure**

	Index	**Formula**
The height- weight index	BMI (Body Mass Index)	$\text{BMI} = \frac{\text{weight(kg)}}{\text{height}\ ^{2}\text{(m)}}$
	Rohrer’s index	$\text{index Rohrera} = \frac{\text{weight(g)}}{\text{height(cm)}}$
	The slenderness index	$\text{UKP} = \frac{\text{height(cm)}}{\sqrt[3]{\text{weight(kg)}}}$
Body proportion, and body build indexes	Manouvrier’s index	$\text{Manouvrier's index} = \frac{\text{the subischial length of the lower limb}}{\text{The height while sitting down}} \text{ x } 100$
	The pelvis- shoulder index	$\text{The pelvis} - \text{shoulder index} = \frac{\text{ic} - \text{ic}}{\text{a} - \text{a}} \text{ x } 100$ ic-ic-pelvis width a-a -shoulder broadness
	Chest index	$\text{Chest index} = \frac{\text{xi} - \text{ths}}{\text{thl} - \text{thl}} \text{ x } 100$ xi-ths- chest depth thl-thl- chest width

The analysis of the results of the study was carried out by means of the Statistica 10.0 program. In all the tests, a relevance level equal to 5 % was adopted. In order to examine the existence of differences in the groups of competitors aged 15, 16, and 17, the one factor analysis of variance was applied. In the case of the examples, where the difference turned out to be statistically significant, a *post-hoc* analysis was carried out to determine, between which age groups there was a difference.

The analyses of the relationship among the somatic build parameters, and the aerobic, and anaerobic capacity parameters, as well as between somatic build indexes, and the aerobic, and anaerobic capacity parameters, were carried out by calculating, and testing the relevance of the correlation coefficient. The correlation analyses were carried out both, for all the groups combined, and for each of the groups separately.

Results

Tables 2 contain the values of somatic indexes determined in the studied groups of hockey players, of the U15, and, U17 teams. The BMI values according to the WHO, are as follows (WHO 1995): underweight< 18.5; proper weight 18,5-24,9; overweight ≥25; obesity ≥30. Rohrer's index acc. to Kowalewska (Malinowski et al., 2000): leptosomic type x-1.12; athletic type 1.13-1.34; pyknic type1.35-x. The slenderness index acc. to Piechaczek et al. (1996): strong build x- 41.54; average build 41.55-44.87; slender build 44.88-x.

Table 2 **The weight-height and body proportion indexes in 15-, and 17-year old hockey players**

Statistics	Weight-height indexes			Body proportion indexes		
	BMI	Rohrer's index	Slenderness index	Manouvrier's index	Pelvis-shoulder index	Chest index
			Team U16			
x	22,41	1,27	43,01	92,91	77,5	70,49
± SD	2,12	0,12	1,36	4,17	8,52	7,2
Max	22,35	1,21	45,42	103,04	92,27	82
Min	26,2	1,52	40,34	86,13	65,43	58,62
			Team U18			
x	23,92	1,33	42,26	93,39	77,4	68,4
± SD	2,36	0,13	1,44	6,67	6,05	6,07
Max	28,05	1,55	45,8	110,84	86,11	78,18
Min	19,05	1,04	40,11	85,65	67,9	60

The classification acc. to (Jagiełło et al., 2011; Tomaszewskiet et al., 2011) was applied to analyze the values in tables 2, Manouvrier's index classifies the lower limbs as: very short: x-74.9; short 75.0-79.9; below average 80.0-84.9; average 85.0-89.9; above average 90.0-94.5; long 95.0-99.9; very long 100.0-x . The pelvis- shoulder index acc. to Wanke classifies the pelvis as: narrow x-71.5;

average: 71.6-76.1, and wide 76.2-x. The chest index acc. to Wanke, classifies the chest as: flat: x-69.7; average: 69.8-75.5, and deep: 75.6-x

The characteristics of body build, and body proportion indexes, calculated on the basis of anthropometric measurements of the ice hockey players, belonging to three age groups, are presented in table 2.In tables 3, relationships between aerobic, and anaerobic capacity indexes, and the weight-height indexes, in all competitor age groupswere presented. In 15 year old competitors, there are relationships between the BMI, and the anaerobic capacity indexes (P_{max} and IF).

In the group of 17 year old hockey players, there are relationships among the BMI, VO_{2max}, andW_{tot}. The statistically significant differences amongthe BMI values, and all (exept for the HR_{max}) aerobic, and anaerobic capacity indexes, were demonstrated in the study group, which was not divided according to age. The Rohrer index, calculated in the 15-, and 17 year old competitors, indicates the athletic body build type (Tomaszewski et al., 2011).

The relationships among the aforementioned weight-height index, and the physiological indexes, in the case, when, the hockey players were not divided into groups, and in the group of the 17 year old competitors, occurred between the same parameters i.e. the Rohrer index, $VO_{2max,}$ and W_{tot}. According to the classification by Piechaczek et al. (1996), the average build type is characteristic of the study participants. Among the competitors, relations were demonstrated among the slenderness index, and $VO_{2max,}$ and all the anaerobic capacity parameters. Negative correlations in the groups of 15-, and 17 year olds, occurred among the same parameters, as in the case of the BMI. In the group pf 15 year old hockey players, relationships were noted among the slenderness index, and the P_{max}, as well as the IF, whereas in the group of the 17 year old competitors, relationships among the slenderness index, VO_{2max} and W_{tot} were observed.

The results of the correlation analysis, without the division into groups, and taking the age of the hockey players into consideration, among the body build proportion indexes, and the aerobic capacity indexes, are presented in tables 4. The values of the Manouvrier's index indicate, that the above average length of the lower limbs, is a characteristic among the hockey players. In the group of the 17 year old hockey players, there is also the statistically significant relationship between the Manouvrier's index, and the $HR_{max.}$ According to the classification devised by Wanke, a characteristic feature of the 15-, and 17 year old hockey players, is a wide pelvis.

In all the groups without division, the pelvis- shoulder index correlates with the W_{tot}. index. According to the classification devised by Wanke, a characteristic feature of the 15-, and 17 year old hockey players, is a wide pelvis. In all the groups without division, the pelvis- shoulder index correlates with the W_{tot}. index. In 15 year old competitors, there was a relationship among the pelvis shoulder index, and the $VO_{2max,}$ and W_{tot}. indexes. In 17 year old hockey players, a relationship was noted between the pelvis -shoulder index, and the HR_{nax}. The values of the chest index, demonstrated that a flat chest was characteristic of 17 year old hockey players, whereas, an average chest was characteristic of 15 year old ones (acc. to Wanke) (Jagiełło et al., 2011).

Table 3 **The correlation coefficient values, and the level of statistical significance (p<0.05) of the relationship among the weight-height and body proportion indexes and aerobic (1) and, anaerobic (2), capacity of the combined U-15, and U-17 groups**.

	Physiological parameters	Weight-height indexes			Body proportion indexes		
		BMI	Rohrer's index	Slenderness index	Manouvrier's index	Pelvis-shoulder index	Chest index
1	VO2max (l/min)	**0,3787**	**0,3855**	**-0,3062**	-0,0235	0,1923	0,1133
		p=,007	**p=,006**	**p=,032**	p=,873	p=,186	p=,438
	VEmax (l/min)	**0,3564**	0,241	-0,2297	0,0737	0,2798	0,1046
		p=,012	p=,095	p=,112	p=,615	p=,052	p=,475
	HR max (ud/min)	0,0464	0,1377	-0,0131	0,085	0,0248	0,1349
		p=,752	p=,345	p=,929	p=,561	p=,866	p=,355
2	Pmax (W)	**0,5855**	0,2527	**-0,4722**	0,083	-0,0123	-0,0776
		p=,000	p=,080	**p=,001**	p=,571	p=,933	p=,596
	Wtot (J)	**0,5064**	**0,4728**	**-0,3937**	-0,1536	**0,3557**	0,143
		p=,000	**p=,001**	**p=,005**	p=,292	**p=,012**	p=,327
	IF (W/s)	**0,5728**	0,189	**-0,5024**	-0,0456	-0,1003	**-0,3128**
		p=,000	p=,193	**p=,000**	p=,756	p=,493	**p=,029**

Table 4 **The correlation coefficient values, and the level of statistical significance of the relationship among the weight-height indexes, and the aerobic (1), and anaerobic (2), p<0.05 capacity of the U-15 and U18 groups**

	Physiological parameters	Weight-height indexes			Body proportion indexes		
		BMI	Rohrer's index	Slenderness index	BMI	Rohrer's index	Slenderness index
		Team U16			Team U18		
1	VO2max (l/min)	-0,274	0,0293	0,2609	**0,8518**	**0,7948**	**-0,7908**
		p=,242	p=,902	p=,267	**p=,000**	**p=,001**	**p=,001**
	VEmax (l/min)	0,2813	0,2261	-0,1856	0,3844	0,2487	-0,2123
		p=,230	p=,338	p=,433	p=,195	p=,413	p=,486
	HR max (ud/min)	-0,0304	0,2655	0,0571	0,1655	0,0192	-0,0024
		p=,899	p=,258	p=,811	p=,589	p=,950	p=,994
2	Pmax (W)	**0,697**	-0,0326	**-0,5863**	0,3546	0,3411	-0,3499
		p=,001	p=,891	**p=,007**	p=,235	p=,254	p=,241
	Wtot (J)	-0,1275	0,1235	0,1001	**0,8357**	**0,7476**	**-0,7129**
		p=,592	p=,604	p=,674	**p=,000**	**p=,003**	**p=,006**
	IF (W/s)	**0,6328**	-0,1654	**-0,5957**	0,4198	0,3502	-0,3656
		p=,003	p=,486	**p=,006**	p=,153	p=,241	p=,219

Table 5 **The correlation coefficient values, and the degree of statistical significance of the relationship among the somatic coefficients, and the aerobic (1), and anaerobic (2) capacity indexes, p<0.05, in the U15, and U 17 groups**

Physiological parameters		Manouvrier's index	Pelvis-shoulder index	Chest index	Manouvrier's index	Pelvis-shoulder index	Chest index
		Team U16			Team U18		
1	VO_2max (l/min)	-0,1376	**0,5037**	0,3298	-0,1913	-0,1016	0,4056
		p=,563	**p=,024**	p=,156	p=,531	p=,741	p=,169
	VEmax (l/min)	0,3182	0,303	0,3952	-0,213	0,0665	-0,0262
		p=,172	p=,194	p=,085	p=,485	p=,829	p=,932
	HRmax (ud/min)	-0,0791	0,3717	**0,5442**	**0,5892**	-0,1684	0,2298
		p=,740	p=,107	**p=,013**	**p=,034**	p=,582	p=,450
2	Pmax (W)	0,1978	-0,2012	-0,1951	-0,1285	-0,4246	0,3893
		p=,403	p=,395	p=,410	p=,676	p=,148	p=,189
	Wtot (J)	-0,3794	**0,5067**	0,1914	-0,1424	-0,0503	0,2823
		p=,099	**p=,023**	p=,419	p=,643	p=,870	p=,350
	IF (W/s)	0,138	-0,2547	**-0,5174**	-0,305	-0,4921	0,1492
		p=,562	p=,279	**p=,019**	p=,311	p=,088	p=,627

Discussion

The results of the studies demonstrated the existence of numerous relationships among body build indexes, and physiological indexes in 15-17 year old hockey players. In the literature of the subject, we find information, that the musculature component can have a significant impact upon the degree of the energy changes and the effective workload value (Angyan et al., 200; Tavinoet et al., 1995). In 15 year old competitors, there are no relationships among the aerobic capacity indexes, and the somatic build ones. The above- mentioned relationships are visible in the groups of hockey players aged 16, and 17 years old. The body mass, and the weight-height indicators in 16, and 17 year old competitors, clearly correlate with maximum oxygen usage (VO_{2max} l/min) The above parameters, and somatic indexes, determine the massiveness of the silhouette, and the degree of muscularity. On the basis of the examination conducted by Janusz & Jarosinska (1981), the participants of which were teenagers from Wroclaw, the total consumption of oxygen (VO_{2max} l/min) was significantly higher among muscular boys, than among those representing the fatty, or the linear body build type. According to Janusz & Jarosinska (1981), the muscular individuals have a greater aptitude for physical effort. In the group of 15 year old hockey players, correlations can be observed among the somatic build parameters, and indexes (body mass, weight-height indexes, the BMI, and the slenderness index, the content of active tissue), and the anaerobic capacity indexes, such as maximum power (P_{max}) and the index of the fall in power (IF). Among the 16 year old competitors, there also are relationships among the above parameters, and somatic indexes, and all the studied anaerobic capacity indexes (P_{max}, W_{tot} and IF). In the group of the 17 year old hockey players, there are relationships among the body mass, all the weight- height indexes, the content of the active tissue, and the absolute value of total work (W_{tot}). Similar relationships relating to body build parameters, and indexes, and the physiological indexes were demonstrated by Byzdra et al. (2015) and Luszczyk et al. (2009) in their studies. In 11 year old football players (boys), a correlation was observed among the body mass, the BMI, and the maximum power (P_{max}), and the total work value (W_{tot}). In another study, Karnia et al. (2010), the participants were tennis players aged 15-18. Significant correlations were observed among the anaerobic capacity indexes, and body mass, and its components, among the youngest participants. According to the authors, 15 year old tennis players have the poorest technical, and tactical skills, which can be compensated by a proper body composition, and a high level of anaerobic capacity. It was also observed, that a large body mass may influence the increase in the value of the index of the fall in power. Burdukiewicz & Janusz (1995) in their studies conducted on the children, and teenagers attending Wroclaw schools, showed that there were significant relationships between mesomorphy, and the value of the work performed. The components of mesomorphyare reflected in the development of the musculature, and in the massiveness of the skeleton, and, as mentioned above, in hockey players, the correlations were demonstrated to concern the parameters, and somatic indexes, which prove the musculature, and the massiveness of the silhouette. In many studies, people competing in various sports disciplines are assigned specific kinds of somatotype (Garay et al., 1974; Leake & Carter, 1991; Farmosi I., 1980; Baxter-Jones, 1995). However, there are not many studies where the question of the relationship between anthropometric indexes, and physiological traits is discussed.

Conclusions

1. There are statistically significant relationships among selected physiological aerobic, and anaerobic capacity indexes in the groups of 15-, and 17 year old hockey players, and the body build indexes, calculated from the value of the mass, and length of the body. Most often, there is a statistically significant relationship among VO_2max, and W_{tot}, and the somatic indicators. In the group of older hockey players (U18), the number of the determined relationships is higher as to all the indexes, compared to the U15 group.
2. The somatic index value, indicates the athletic body build type of the hockey players. This build type demonstrates relationships among aerobic and

anaerobic capacity in the U 18 group of hockey players. This relationship was not observedduring the earlier stages of training.

3. The body build proportions demonstrate, that the hockey players are a group with long lower limbs, wide pelvises, and flat chests. In all groups, without the division into age groups, the pelvis-shoulder index correlates with the $W_{tot.}$ In the U15 player group, a relationship was noted among the pelvis-shoulder index, the $VO_{2max,}$ and W_{tot}. In 17 year old hockey players, a relationship was noted between the pelvis-shoulder index, and the HR_{max}

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