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Somatic and functional variables determining game efficiency of ice hockey players

by

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Ice hockey is a sport discipline, in which championship performance is mainly determined by functional features and somatic variables. The main goal of this paper was the estimation of values of basic somatic features and selected fitness variables, as well as their relationships, in ice hockey players of different level. The research was carried out on members of national teams, in four age groups: under 16 (U-16), under 18 (U-18), under 20 (U-20) and above 20 (A-20). Twenty eight variables were chosen for evaluation of somatic constitution. Based on absolute values of somatic features, 5 indexes were calculated, as well as fat and fat free mass content in tested subjects. For evaluation of fitness a test battery was used, which according to coaches and experts show the highest validity in determining the requirements for competition in ice hockey. To determine the relationships between somatic variables and fitness indexes the correlation analysis was used. The results of carried out analyses indicate that body mass and its components are of greater importance than body height and length variables in ice hockey. Body mass in seniors shows a high relationship with many fitness variables, among them the most important - associated with anaerobic capacity. The results also indicate that basic somatic features in ice hockey players, playing different positions (forwards and defenders) differ significantly. Defenders have greater body mass and are slightly taller than forwards.
***Keywords**: ice hockey, somatic traits, anaerobic fitness, game effectiveness*

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Introduction

Ice hockey is one of the quickest and most spectacular team sport games. Rules that enable hard body checking make the game dynamic and spectacular. Good skating skills, stick operation and puck mastery make ice hockey very impressive. Achieving championship performance in ice hockey requires a high level of conditioning and coordination. As a sport discipline it also places specific requirements on somatic traits necessary for game effectiveness. Identification of body function indexes and somatic variables is necessary for effectiveness not only in competition but also in training, as well as in determining the criteria of selection of candidates for ice hockey.

The main goal of this paper was to determine the somatic variables and body function indexes that influence game efficacy of Polish hockey players.

Material and methods

The research material included anthropometric variables and body function indexes of 126 elite hockey players, from the Polish national teams in four age categories: U-16, U-18, U-20 and A-20 Polish national team members. In each age group the research was carried out twice or three times during an annual training cycle. For analyses the results of research conducted before the World Championships in particular age categories were taken into account.

From among all hockey players under research a group of 15 athletes was chosen for longitudinal research, starting when they were Polish national team members of U-16 and ending when being Polish representatives of U-20 group.

Additionally data concerning two somatic variables, body mass and body height, of 6 national teams taking part in the Olympic Games of 2002 were used.

For anthropometric evaluation of hockey players under research, 28 somatic traits were used (Agre et al., 1988). Variables associated with body height (length variables) and body mass (girth variables) were taken into account. Measurements of girth variables determining body mass were also taken. Skinfold measurements were taken to calculate fat content (F%) and fat free mass (FFM%). For more detailed characteristics of body constitution, besides absolute values of somatic traits, also indexes enabling the assessment of body proportions and somatic type were calculated.

The following indexes were calculated:

- Trunk Index [ssy-sy/B-v]x100,
- Shoulder Index [a-a/sst-sy]x100,
- Pelvis Index [ic-ic/a-a]x100,
- Chest Index [xi-ths/thl-thl]x100,

- Rohrer Index.

Consequently, in all hockey players under research the somatic type of all competitors according to A. Wanke typology was determined.

For evaluation of functional indexes, test batteries were adopted, which according to experts are most frequently used in research on ice hockey.

1. For determination of anaerobic power under laboratory conditions the 30s Wingate test was used, carried out according to Bar-Or et al. (1977), Inbar et al. (1986) and Szestiakov et al. (2000) procedures. The test variables were registered with a computer programme MCE v2.2. The test effort was preceded by a 5 minute warm-up on the cycle ergometer. The load was set individually for each subject at 75g/kg of body mass. The following variables were calculated:

- Maximal power (W),
- Relative power (W/kg),
- Total work (kJ),
- Relative work (kJ/kg),
- Time of reaching maximal power (s),
- Time of sustaining maximal power (s).

2. For evaluation of specific anaerobic endurance a 5 x 54 m shuttle skate test carried out on ice was used.

3. Additionally a lower extremity power test was used - "jumping ability test". Such a test was carried out both before the Wingate test and immediately after it. Five consecutive vertical jumps were measured, with the use of Ergo Tester apparatus with a tensometric mat (Globus Italia S.r.l.), the following data was registered:

- Maximal power (W),
- Time of contact with the ground (s),
- Jump height (m).

For evaluation, average values of five jumps were taken into account. The changes of particular variables before and after the Wingate test gave indirect information about the level of anaerobic power of the athletes.

In data processing the following methods were adopted: quantitative analyses (arithmetic averages, standard deviations, t-test) as well as result-reason analyses and Pearson correlations.

The following hypotheses were assumed:

1. Somatic variables play a significant role in determining the level of ice-hockey game effectiveness. Somatic variables, which achieve the highest values in elite athletes should be regarded as most significant for this sport discipline.

2. Variables, which achieve highest values in senior athletes, are also regarded as most important elements of conditioning in ice hockey.
3. Athletes playing various positions (forwards or defenders) differ in both somatic constitution and fitness level.
4. The level of achievements in each sport discipline, also ice hockey, is determined not only by absolute values of somatic constitution and physical fitness indexes, but also their coordinated interaction. The correlation coefficients between somatic variables and physical fitness indexes, which are observed in elite athletes, also determine game effectiveness in hockey.

Results and discussion

A comparative characteristic of basic somatic traits shows that greatest differences between teams under research occur in body mass and functional variables. Besides substantial differences in body mass and girths, differences also occur in calculated indexes, as well as in widths of bases of upper and lower extremities. All these variables achieve highest values in the group of hockey players from Polish senior national team (Table 1).

Such considerable differences in body mass and related variables, as well as differences in widths of bone bases and some other indexes show that these traits attain highest values in the senior group and are essential for success in ice hockey. This is confirmed by other research (Bashkirow et al. 1968, Gowarzewski 1983, Horsky 1981, Nikitushkin et al. 1998, Socha 1982).

A comparative analysis of somatic traits shows that variables associated with body height are not different in considered teams. One can assume that for attaining significant results in ice hockey, body height is not as important as body mass. It should be underlined that body height is determined genetically and training loads have little effect on it. Body height is foremost the result of selection, and not of external factors, such as training. However body mass may be changed significantly through training, diet and supplementation.

The presented somatic characteristics according to Wanke typology shows, that the dominant somatic type in athletes in all teams is the VHIA type (Table 2). Only in the youngest group (up to 16) the relation of particular factors is different, with superiority of the “I” factor over “H”.

Table 1

Comparative characteristics of somatic traits in analyzed hockey players.

Somatic traits	U-16		U-18		U-20		Senior team*	
	Value	%	Value	%	Value	%	Value	%
Body mass	76.26	91.1	75.88	90.6	80.29	95.9	83.73	100
B-v	179.68	99.9	177.24	98.5	182.13	101.3	179.85	100
Sst-sy	53.19	99.2	51.85	96.7	54.14	101.0	53.60	100
a-da3	79.57	100.7	77.34	97.8	80.59	102.0	79.04	100
B-tr	95.54	101.8	93.43	99.6	95.85	102.2	93.83	100
a-a	40.80	96.5	41.37	97.8	42.17	99.7	42.30	100
thl-thl	27.91	96.2	27.65	95.3	29.09	100.2	29.02	100
xi-ths	19.25	97.6	19.94	101.1	20.92	106.0	19.73	100
ic-ic	28.32	96.3	28.31	96.3	29.04	98.8	29.40	100
Chest girth	87.83	91.4	86.66	90.2	89.67	93.3	96.08	100
Waist girth	78.76	93.8	77.98	92.9	80.25	95.6	83.97	100
Hip girth	93.17	90.9	96.23	93.8	99.33	96.9	102.54	100
Arm girth	28.31	89.9	28.75	91.3	29.88	94.9	31.50	100
Forearm girth	26.19	92.0	26.70	93.8	27.21	95.6	28.46	100
Thigh girth	56.54	91.9	56.98	92.6	58.85	95.6	61.54	100
Shank girth	36.80	99.7	35.14	95.2	36.81	99.7	36.92	100
Arm circumference	7.32	96.6	7.34	96.8	7.55	99.6	7.58	100
Forearm circumference	5.64	97.6	5.45	94.3	5.63	97.4	5.78	100
Thigh circumference	9.94	96.2	9.85	95.4	10.19	98.6	10.33	100
Shank circumference	7.66	96.4	7.58	95.3	7.84	98.6	7.95	100
TA kg	59.96	92.0	52.61	80.7	62.73	96.3	65.17	100
F%	15.56	100.9	13.80	89.5	15.36	99.6	15.42	100

values of somatic variables of senior national team athletes were assumed as 100%.

Table 2

Comparison of somatic constitution of athletes in particular age groups according to Wanke typology.

Group	V	I	H	A	Type
U-16	49.1	23.1	16.3	11.6	VIHA
U-18	52.51	14.07	23.45	9.96	VHIA
U-20	57.2	15.9	17.4	9.5	VHIA
Senior (A-20)	49.1	14.3	25.8	10.7	VHIA

An assumption was made that defenders and forwards differ in body mass and body height. These differences make somatic conditions of various positions played in competition. Such an assumption has been verified on the example of somatic traits of Polish senior national team members. The results of research only partly confirm the basic assumption, because the differences concern body mass (5.6 kg), while body height differences remain inside the limits of measurement error (Table 3). The somatic constitution of Polish hockey players cannot be regarded as optimal, because they represent an average sport level in the world. A somatic model may be regarded as the one represented by best national teams in the world (Table 3.).

Table 3

Average values of basic anthropometric variables of hockey players from national teams taking part in Olympic Games in Salt Lake City in 2002.

	Body height			Body mass		
	defenders	forwards	team	Defenders	forwards	team
Czech Republic	189.71	185.08	186.70	96.43	86.54	86.00
Canada	187.00	183.46	184.70	92.14	89.92	90.70
Russia	187.00	183.08	184.32	94.67	87.38	89.68
Slovakia	186.43	182.92	184.21	96.00	87.75	90.05
Sweden	187.86	185.62	186.40	91.71	90.08	90.65
USA	185.43	185.23	185.30	91.00	92.31	91.85
X	187.33	184.60	185.70	93.66	89.00	91.12
Poland	180.17	179.40	179.85	86.06	80.46	83.73
Differences	+7.16	+5.20	+5.85	+7.60	+8.54	+7.39

Hockey players from these six countries have much higher body mass (on the average 8%) and body height (on the average 3%) than Polish athletes. Greater are also differences in somatic constitution of these 6 teams between forwards and defenders. The differences in somatic constitution of the Polish national team and the best hockey players in the world are the most important causes of the low sports level of Polish athletes.

The differences in functional variables between ice hockey teams (age groups) under research are much greater than those of somatic traits. The greatest differences occur in total work performed during the 30-second Wingate test (Table 4.). The hockey players from U-16 group performed on average about 29% less work, and from U-18 – about 20% less work than A-20 athletes. Also significant are the differences between particular age groups in maximal power. As far as this variable is concerned, during the Wingate test the worst results are achieved by hockey players from the youngest group (on the average 78% of senior achievements).

Table 4

Comparative characteristics of fitness indexes in analyzed groups of hockey players.

Variables	U - 16		U - 18		U – 20		Senior representation*	
	Value	%	Value	%	Value	%	Value	%
P max [W]	782.41	78.1%	832.95	83.2%	915.46	91.4%	1001.25	100
P max [W/kg]	10.24	87.1%	11.01	93.6%	11.38	96.8%	11.76	100
Total work [kJ]	18.55	71.3%	20.75	79.8%	22.61	86.9%	26.01	100
Time of P max reaching [s]	5.37	80.70%	4.47	99.3%	4.14	92.0%	4.50	100
Time of P max sustaining [s]	3.60	87.4%	4.39	106.6%	4.05	98.3%	4.12	100
Height of I series of jumps [m]	0.379	100.5%	0.340	90.2%	0.379	100.5%	0.377	100
Height of II series of jumps [m]	0.269	100.0%	0.257	95.5%	0.288	107.1%	0.269	100
Jump-off time in I series of jumps [s]	0.283	113.7%	0.200	80.3%	0.243	97.6%	0.249	100
Jump-off time in II series of jumps [s]	0.346	111.3%	0.277	89.1%	0.291	93.6%	0.311	100
Shuttle skate 5 × 54m [s]		0.0	43.38	114.1%	43.96	115.6%	38.02	100

results of senior national team athletes were assumed as 100%.

Considerable differences are also observed in the 5x54m shuttle skate. In the youngest group coaches did not conduct this test which yields the best characteristics of specific metabolic pathways of hockey players. The senior athletes attained results about 15% better than the members of two other groups.

The differences in time of reaching maximal power and time of sustaining maximal power are much lower. The former is regarded as a manifestation of strength-speed abilities, while the latter as a manifestation of strength-endurance abilities. Hockey players from the U-16 group attained worse results than members of other groups. The strength-speed abilities of the U-16 group were 20% worse then those of athletes from other groups. The jumping variables were similar in all groups.

It is worth noticing that the differences in fitness variables are much greater than the differences in basic somatic variables between teams under research. Much greater differences of fitness are determined by external stimuli, as training and competition loads, and lack of limitations occurring by differentiation of somatic variables. After completing the development processes and gaining biological maturity, the natural processes of differentiating somatic traits stop. Under influence of external stimuli, especially strength training, the variables associated with body mass undergo some modification. On the other hand, improvements in the level of fitness continue after reaching maturity. There are greater differences among teams under research in the level of fitness as compared with somatic variables. The perfecting of selection methods based on somatic variables is possible only in defined age limits, while the perfecting of functional variables is free of such time limitations (Baladin et al. 1986).

The described phenomenon was most completely revealed in the group of hockey players taking part in longitudinal research. Body height and relative variables in the period of 2 years increased only inside limits of measurement error. On the other hand, body mass and relative somatic variables increased by 5% with a simultaneous decrease in fat content by 10%. During this time period maximal power increased by 14% and total work by 11.5% (Table 5).

The presented analyses are quantitative ones and inform about differences between particular teams in somatic traits and fitness indexes. From a cognitive and practical point of view more important are the cause-effect analyses, concerning relationships between somatic traits and fitness indexes under research. The existing relationships may be regarded as a harmony of functional abilities with somatic variables, determining the level of athlete's performance.

Table 5

Differences in somatic traits and functional indexes between first and last series of test trials.

	First series of research	Last series of research	Differences %
Body mass [kg]	77.44	80.78	4.3
Body height [cm]	182.03	184.79	1.5
Fat free mass (FFM) [kg]	65.22	69.30	6.3
Fat content (FT) [%]	24.79	14.22	-10.57
P max [W]	809.50	920.60	13.7
P max [W/kg]	10.74	11.59	7.9
Total work [kJ]	20.46	22.83	11.5

The analyses of correlations were performed on two groups extremely differing in sports level: U-16 and senior ones. In the U-16 group only two fitness variables, maximal power and total work, show significant relationships with body mass and relative somatic variables, mainly girth and FFM content (Table 6). However, the relationships with body height and relative somatic variables are weaker. The other variables have no relations with somatic traits.

Maximal power is significantly related not only with body mass and similar variables, but also with body height and length variables. Similar are the relations between total work and somatic traits. Unlike U-16 group, the results of the jumping test show distinct relations with most somatic traits. First of all it concerns body mass and related variables. Significant correlations with FFM and girth of lower extremities show that functional fitness of lower limb muscles is the crucial factor in efforts specific for ice hockey. In other groups such connections were not observed. In the senior group significant correlations were determined between results of the shuttle skate 5 × 54 m and somatic traits. The results of the skate are correlated only with body mass and related variables. Body height and related length variables have no significant relations with results of the shuttle skate.

According to the preliminary assumption, the relationship between body constitution and functional abilities may be regarded as characteristic for elite senior hockey players.

Table 6

Correlation coefficient values between selected somatic traits and selected functional indexes in hockey player U-16 group.

Variable	Max. power	Relative max power	Total work	Time of max. power reaching	Time of max. power sustaining	Average height of I series of jumps	Average height of II series of jumps	Jump-off time in I series of jumps	Jump-off time in II series of jumps
Body mass	0.83	0.29	0.81	-0.34	0.21	-0.04	-0.02	0.14	0.03
Body height	0.46	0.14	0.49	-0.34	0.32	0.01	-0.15	0.22	0.21
Trunk length	0.20	0.18	0.22	0.35	-0.02	0.14	-0.07	0.25	0.15
Upper extremity length	0.49	0.04	0.49	-0.44	0.24	-0.07	-0.29	0.18	0.16
Lower extremity length	0.49	0.13	0.44	-0.63	0.19	0.02	-0.30	0.05	0.19
Shoulder width	0.43	0.32	0.31	-0.31	-0.24	0.18	0.16	-0.20	-0.20
Pelvis width	0.65	0.41	0.64	-0.19	0.06	-0.02	0.02	0.06	-0.01
Chest girth	0.48	0.12	0.46	0.03	0.10	-0.04	-0.04	0.04	0.00
Waist girth	0.73	0.35	0.72	-0.20	0.27	0.04	0.07	0.11	-0.02
Hip girth	0.32	-0.08	0.37	-0.17	0.15	-0.44	-0.05	0.24	0.08
Arm girth	0.58	0.41	0.47	-0.11	-0.16	0.19	0.33	0.11	0.03
Forearm girth	0.59	0.36	0.42	-0.14	-0.16	0.30	0.10	-0.07	0.02
Thigh girth	0.73	0.34	0.77	-0.23	0.24	-0.06	0.31	0.13	-0.05
Shank girth	0.45	0.05	0.47	-0.13	0.11	-0.23	-0.24	0.19	0.01
Arm circumference	0.45	0.18	0.39	-0.44	0.21	0.05	-0.09	0.05	0.06
Forearm circumference	0.31	0.04	0.17	-0.19	-0.02	-0.05	-0.16	0.10	0.14
Thigh circumference	0.52	0.30	0.45	-0.30	0.06	0.14	0.09	0.20	0.06
Shank circumference	0.41	0.26	0.43	-0.30	0.16	0.19	-0.06	0.30	0.18
F %	0.16	-0.13	0.34	0.03	0.27	-0.48	0.05	0.15	-0.11
FFM kg	0.65	0.13	0.68	-0.27	0.29	-0.16	-0.20	0.25	0.15
Rohrer index	0.31	0.04	0.17	-0.19	-0.02	-0.05	-0.16	0.10	0.14

($p<0.05$ $r=0.42$)

In the senior group correlations between somatic traits and functional indexes are more pronounced (Table 7).

Table 7

Correlation coefficient values between analyzed somatic traits and selected functional indexes in senior national team hockey players.

Variable	Max. power	Relative max power	Total work	Time of max. power reaching	Time of max. power sustaining	Average height of I series of jumps	Average height of II series of jumps	Jump-off time in I series of jumps	Jump-off time in II series of jumps	Shuttle skate 5×54m
Body mass	0.55	-0.47	0.54	0.13	0.15	0.68	-0.20	0.63	0.30	-0.53
Body height	0.35	0.42	0.53	-0.22	0.25	0.32	-0.28	0.12	-0.17	0.11
Trunk height	0.18	0.31	0.14	-0.04	0.04	0.33	-0.36	0.16	-0.19	-0.47
Upper extremity length	0.36	0.45	0.49	0.05	0.07	0.37	-0.30	0.09	-0.05	0.27
Lower extremity length	0.43	0.52	0.44	-0.21	0.35	0.21	-0.18	0.05	-0.31	-0.08
Shoulder width	0.19	0.36	0.07	-0.19	-0.06	0.33	-0.27	-0.14	0.03	0.04
Pelvis width	-0.06	-0.14	0.33	-0.14	0.48	0.48	-0.09	0.39	0.28	0.33
Chest girth	0.15	0.28	-0.20	0.46	0.00	0.06	-0.32	0.25	0.37	0.09
Waist girth	0.11	0.12	0.02	0.13	0.32	0.55	-0.25	0.52	0.77	0.37
Hip girth	0.53	-0.43	0.32	0.12	0.04	0.63	-0.15	0.64	0.49	-0.59
Arm girth	0.27	0.16	0.18	-0.18	-0.10	0.42	-0.15	0.33	0.49	0.39
Forearm girth	0.51	-0.38	0.53	-0.16	-0.31	0.18	-0.02	0.23	-0.06	-0.02
Thigh girth	0.26	0.17	0.01	0.13	-0.10	0.51	0.00	0.64	0.49	-0.61
Shank girth	0.24	0.28	-0.03	-0.27	-0.54	0.31	-0.04	0.13	0.25	0.25
Arm circumference	-0.22	-0.34	-0.09	0.40	0.14	0.32	0.07	0.30	0.62	0.29
Forearm circumference	0.12	0.05	0.43	-0.08	-0.13	-0.66	0.03	-0.35	-0.25	-0.82
Thigh circumference	0.70	-0.60	0.56	-0.29	-0.26	0.63	0.19	0.33	-0.09	0.27
Shank circumference	0.57	0.35	0.67	-0.03	0.00	0.79	0.35	0.31	-0.03	-0.46
Fat content (FT) %	0.03	0.11	-0.31	-0.10	-0.18	-0.56	-0.40	0.39	0.29	0.38
Fat free mass (FFM) %	0.56	-0.69	0.31	-0.10	-0.47	0.41	0.04	0.03	0.30	- 0.48
Rohrer index	0.14	-0.03	-0.08	0.37	-0.11	0.29	0.14	0.47	0.46	0.37

($p<0.05$ $r=0.42$)

Conclusions

1. The assumptions made in this work have been to great extent positively verified by the results of carried out research.
2. From among analyzed somatic traits, body mass and its components determine the sports level of hockey players to a greater extent than body height and length variables.
3. The assessment of somatic constitution of Polish senior team does not confirm the assumption that hockey players, defenders and forwards, differ significantly in somatic variables. This assumption is fully confirmed in elite world teams, where defenders have significantly greater body mass and body height.
4. The results of the Wingate test and shuttle skate 5×54 m, in which senior national team athletes reached best results may be regarded as specific for evaluation of performance in ice hockey.
5. The relationship between functional indexes and somatic variables determined in the senior group may be regarded as typical for high-class hockey players.

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