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RELATIONSHIPS OF PHYSICAL FITNESS TEST RESULTS AND PLAYER PERFORMANCE INDICATORS IN NATIONAL-LEVEL ICE HOCKEY PLAYERS

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Abstract. *The aim of the study is to identify the relationships of the results of the physiological and anthropometric tests and special on-ice fitness tests with individual player performance indicators during matches of the Poland men's national ice hockey team played during the U18 Ice Hockey World Championship. A total of 20 hockey players (forwards, n=12 and defensemen, n=8) of the Poland men's national ice hockey team were included in this study. All participants were performed a battery tests including maximal aerobic capacity, Wingate test, Repeated-Skate Sprint test and vertical jump test. Pearson correlations were used to examine any differences in all measures and +/– score. Only the fatigue index calculated from the repeated-skate sprint test was significantly correlated with absolute +/– score (r=0.47, p<0.05). The result of the aerobic capacity test, expressed by means of the oxygen intake value (*$\dot{V}O_2max$*), despite being statistically insignificant, reached the value of r=0.42. The results of this study suggest that game performance as indicated by the +/– score can be predicted by the fatigue index calculated from the repeated-skate sprint test.*
Keywords: *ice hockey testing, body composition, aerobic fitness, performance indicators.*

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Introduction

Ice hockey belongs to the group of sports where both offensive and defensive players perform intermittent high-intensity bouts of exercise with short durations and generate maximal power that allows for performing frequent accelerations and dynamic changes in directions of skating on ice (Bishop, Lawrence, & Spencer, 2003; Buchheit, Lefebvre, Laursen, & Ahmaidi, 2011; Roczniok, Stanula, Maszczyk, et al., 2016). Ice hockey is a physically demanding and contact sport that requires comprehensive preparation of the athlete in terms of aerobic and anaerobic capacity and muscular strength (Stanula, Roczniok, Maszczyk, Pietraszewski, & Zając, 2014). Furthermore, optimal body composition and body build plays an important role in the achievement of high effectiveness during the game (Montgomery, 1988).

In order to maintain a high level of physical fitness, hockey players perform various tests on ice and in a laboratory environment, both in the preparation period and over the entire season (Roczniok, Stanula, Gabryś, et al., 2016). The results of such tests help establish the relationships between the results of physiological and anthropometric tests and physical fitness of players and player performance indicators (Green, Pivarnik, Carrier, & Womack, 2006). These activities are aimed to help determine the effect of individual components of training on sports performance and, consequently, make it easier for coaches to choose adequate variants of athletic training process (Durocher, Leetun, & Carter, 2008).

Previous literature has identified various off-ice testing variables as predictors of on-ice performance (Behm, Wahl, Button, Power, & Anderson, 2005; Bracko & George, 2001). The off-ice tests most frequently applied to evaluate the physical fitness of hockey players, are 40-yd running tests, during which the elements of acceleration, and maximum velocity are also evaluated (Diakoumis & Bracko, 1998). Behm et al. (2005), also recommend to include the evaluation of the power of the lower limbs by means of the vertical jump test, into the evaluation of the physical fitness of the hockey players. Farlinger, Kruisselbrink, & Fowles (2007), in turn, suggest other off-ice measures, including measures of overall leg power (Wingate power), horizontal power (30-m sprint, broad jump, 3 hop jump) lateral power and agility (Hexagon agility), and general strength and stability (push-ups, side support), which, in their opinion are highly interrelated with on-ice skating sprint performance, and cornering agility. In turn, in the group of tests evaluating the physiological predispositions of the competitors, aerobic, and anaerobic capacity tests, are applied. Both anaerobic and aerobic capacities, are currently measured during cycle ergometer protocols (Burr et al., 2008). However, researchers emphasize, that the lack of similarity between the structure of the movement performed during the off-ice test, and the activities performed during play, proves the low prediction value of the tests

(Bracko & George, 2001; Stanula & Roczniok, 2014; Vescovi, Murray, Fiala, & VanHeest, 2006).

The aim of the study is to identify the relationships of the results of the physiological and anthropometric tests and special on-ice fitness tests with individual player performance indicators during matches of the Poland men's national ice hockey team played during the U18 Ice Hockey World Championship.

Materials and Methods

Subjects. All forwards (n=12) and defensemen (n=8) of the Poland men's national ice hockey team who played on the U18 Ice Hockey World Championship were included in this study. Their mean (±SD) age was 17.3 ± 0.6 years and 17.0 ± 0.8 years, height 178.8 ± 5.9 cm and 181.0 ± 5.0 cm, and body mass 74.5 ± 9.9 kg and 79.5 ± 9.0 kg, respectively for forwards and defensemen. Goaltenders were not included in analysis because they have a distinctly different role in the game and therefore require a different skill set to be successful. Written informed consent was obtained from all participants and parents after a brief but detailed explanation about the aims, benefits, and risks involved with this investigation. The research project was approved by the Bioethics Commission at the Regional Medical Chamber in Krakow as consistent with the institutional ethical requirements for human experimentation in accordance with the Helsinki Declaration.

Procedures

Anthropometric and physiological data of the test was carried out 2 weeks before the World Championships. Body height was determined including barefoot height (± 0.1 cm) using a wall mounted stadiometer. Body composition was estimated using an 8-electrode bioimpedance analysis device (InBody 720, Biospace). All the measurements were taken by a certified representative of MEDfitness, a sole distributor of the InBody body composition analyzer in Poland. Body weight measurement was taken in the morning (09.00-10.00 a.m.), two hours after a light breakfast.

Vertical Jump. Vertical jump height was measured using a Optojump photocell system (Microgate, Bolzano, Italy). The jumps were performed with an arm swing and use of the stretch shortening reflex in a stationary position (no pre-step). Subjects completed 2 trials and the best trial was recorded. A rest period of 30 seconds was given between trials. Jump heights were recorded to the nearest 0.1 cm. Peak vertical jump power was calculated using the Sayers equation: *power (W) = [60.7 × vertical jump displacement (cm)] + [45.3 × weight (kg)] – 2055.*

30-Second Wingate test. Wingate test was performed on Cyclus 2 (RBM electronik-automation GmbH Germany). The test was carried out according to the following protocol: the load was selected individually and it constituted 10 % of the body weight, the test was preceded by a 5-min warm-up with the 30 % load of that used during the test and with a revolution frequency of 60 revolution per minute. After the warm-up and 3-min break each subject began the test with full load from the frequency of 100 ± 16 revolution per minute (differently than in the Wingate protocol). The subjects started to exercise with maximal intensity. When 30 rpm was achieved, the load was activated automatically to continue for 30 seconds. In that period, the subjects were to maintain maximum rotational frequency. The following parameters were recorded during the test: absolute peak power (W), mean power (W), relative peak power ($W \times kg^{-1}$) and relative mean power ($W \times kg^{-1}$).

Standard Incremental Maximal Oxygen Uptake ($\dot{V}O_2max$) Test to the Point of Exhaustion. A standard incremental maximal oxygen uptake test was conducted in the laboratory by means of open-circuit spirometry and computerized instrumentation. Each subject performed the test until voluntary exhaustion on a cycling ergometer platform Cyclus 2 (RBM elektronik-automation GmbH, Leipzig, Germany). Prior to the test, the players warmed up on the ergometer for 5 minutes of steady ride at power level of 1 $W \cdot kg^{-1}$ after which exercise intensity was increased to 4 $W \cdot kg^{-1}$ for a duration of 10 seconds. The first 3 minutes of the test were completed at an intensity of 1 $W \cdot kg^{-1}$ of body weight, and then intensity was increased every 3 minutes by 0.5 $W \cdot kg^{-1}$ of body weight. Exhaled air was continuously sampled by an K4b2 (Cosmed, Italy) and the rate of oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), minute ventilation ($\dot{V}E$), and the respiratory exchange ratio (RER) were calculated every 5 seconds by an on-line computer system. The K4b2 was calibrated in accordance with the manufacturer's specifications at the beginning of each test day. The test was stopped if the subject wished so or if the $\dot{V}O_2max$ criteria were met (e.g. RER greater than 1.10 at test termination; oxygen consumption reaching a plateau or starting to fall even though the work rate kept increasing or the maximal age-specific heart rate was reached) (Davis, 2006; McArdle, Katch, & Katch, 2010). Throughout the test, HRs were recorded every 5 seconds by means of a Fix Polar Heart Rate Transmitter Belt (Polar electro OY, Kempele, Finland).

Repeated-Skate Sprint test (RSS). Each subject completed the Repeated-Skate Sprint test (RSS) consisting of 6 timed 89-m sprints, with 30 s of rest between subsequent efforts (Reed et al., 1980). Subjects wearing full hockey equipment except for the stick performed 6 timed 89 m sprints at the highest velocity, with 30 s of a rest period between subsequent efforts. Before the test commenced, each subject carried out an individual 5 min warm-up with elements such as skating forward, skating backward, starts and stops. Each test sprint started at the goal line. Having crossed the opposite goal line (54 m) with both skates the player would stop immediately and then skated back towards the blue

line situated closer to the start line (89 m), the crossing of which ended the sprint. Exactly 30 s after he crossed the blue line the player would skate again. Photocells made by Microgate (Bolzano, Italy) recorded the times of each sprint with accuracy of 0.01 s, separately for the length between the start line and the opposite goal line (54 m) and between the latter and the blue line closer to the start line (35 m). Together with the time of the return, the two times consisted the total time of one sprint (89 m). The indicators were respectively FLS (the time of the first length skate) and TLS (the total time of the whole distance). Furthermore, a fatigue index (FI) was calculated from the following formula ((the fastest skate time – the slowest skate time)/the fastest skate time) x 100).
Testing was conducted on 3 separate days. Day 1: Anthropometrics, Vertical jumps and $\dot{V}O_2max$, day 2: Wingate test, day 3: repeated-skate sprint test.

The principal outcome measure of hockey performance in this study was the +/– score recorded for each player over the course of the U18 Ice Hockey World Championship. Player is credited with a plus every time he is on the ice and the team scores an even strength or shorthanded goal. A player receives a minus every time he is on the ice and the other team scores an even strength or shorthanded goal. Power play goals and penalty shot goals are not used in the +/– score. A player's overall +/– score is calculated by subtracting the minuses from the pluses. In general, players with a higher total are considered to be better players. An advantage of the +/– system is that it reflects both offensive and defensive effort and is not largely impacted by games missed due to illness, injury, or position played in the way that total goals scored might be (Peyer, Pivarnik, Eisenmann, & Vorkapich, 2011).

Statistical analysis. Descriptive statistics including mean ± standard deviations (SD) were calculated for each variable. All variables were examined for normal distribution. Differences between the forwards and defensemen players were established with the two-tailed t-test for independent variables. The relationships between variables obtained from the all tests and +/– score were determined with the Pearson's product-moment correlation analysis. The level of significance was set at 0.05 for all tests. Calculations were performed with the Statistica 13 statistical software package (Dell Statistica, Dell Inc., USA).

Results

Anthropometric and physiological characteristics of participants are shown in Table 1. On the basis of the presented results, it can be stated, that the forwards are slightly taller, and have a slightly lower body mass, as compared to the defensemen. However, these differences are not statistically significant. It can also be noted, that there is a slight, statistically insignificant difference in the

$\dot{V}O_2max$, and the relative values of the power obtained in the Wingate test, to the benefit of the forwards.

Table 1 **Descriptive characteristics of forwards and defensemen of Poland men's national ice hockey team played during the U18 Ice Hockey World Championship**

Variables	Forwards (n=12)	Defensemen (n=8)	p-level	Total (n=20)
Age (y)	17.3±0.6	17±0.8	0.429	17.2±0.7
Body mass (kg)	74.5±9.9	79.5±9	0.268	76.5±9.7
Height (cm)	178.8±5.9	181±5	0.389	179.7±5.5
% FAT	9±2.8	11.8±3.6	0.064	10.1±3.3
FFM (kg)	67.6±7.6	69.9±6	0.500	68.5±7
Vo_2max ($ml\times kg^{-1}\times min^{-1}$)	58.8±3.9	58.3±4.8	0.769	58.6±4.2
HRmax ($b\times min^{-1}$)	182.6±6.9	186.6±7.8	0.238	184.2±7.4
WAPP (W)	954±133,8	1055±165,7	0,150	994±151,8
WAMP (W)	763±99,3	817±115,2	0,272	785±106,6
WRPP ($W\times kg^{-1}$)	13±0,6	13,2±1,3	0,648	13,1±0,9
WRMP ($W\times kg^{-1}$)	10,4±0,7	10,3±0,9	0,701	10,4±0,7
VJH (cm)	41,8±3,2	41,1±3	0,650	41,5±3
VJPP (W)	3854±410,6	4041±470,8	0,359	3929±433,7
RSS TLS-F (s)	13,5±0,3	13,6±0,4	0,549	13,5±0,4
RSS TLS-Avg (s)	14,8±0,4	14,5±0,3	0,064	14,7±0,4
RSS TLS-Fi (s)	15,1±1,3	14,9±1,1	0,765	15±1,2
Plus/minus	-3,1±2,8	-2,8±1,3	0,756	-3±2,3

The Pearson correlation coefficients between anthropometric and on- and off-ice variables are shown in Table 2. From among all the parameters attained as result of the measurements carried out, only the fatigue index calculated from the repeated-skate sprint test was significantly correlated with absolute +/– score ($r=0.47$, $p<0.05$). Nonetheless, it's noteworthy that the result of the aerobic capacity test, expressed by means of the oxygen intake value ($\dot{V}O_2max$), despite being statistically insignificant, reached the value of $r=0.42$. In addition, the $\dot{V}O_2max$ is significantly correlated with the Wingate test results ($r=0.57$, $p<0.01$ and $r=0.53$, $p<0.05$ for absolute peak power and absolute mean peak power, respectively), the results of vertical jumps ($r=0,63$, $p<0.01$ for vertical jump peak power) and also with the fatigue index calculated from the repeated-skate sprint ($r=–0.62$, $p<0.01$).

Table 2 **Pearson correlations among major variables for the entire sample**

	Age	Body mass	Height	% FAT	FFM	Vo_2max	HRmax	WAPP	WAMP	WRPP	WRMP	VJH	VJPP	RSS TLS-F	RSS TLS-Avg	RSS TLS-Fi	Plus/minus
Age (y)	–																
Body mass (kg)	0.06	–															
Height (cm)	–0.17	0.86	–														
% FAT	0.14	0.79	0.60	–													
FFM (kg)	0.01	0.97	0.87	0.62	–												
Vo_2max ($ml \times kg^{-1} \times min^{-1}$)	0.17	–0.59	–0.69	–0.33	–0.62	–											
HRmax ($b \times min^{-1}$)	0.29	–0.08	–0.20	0.09	–0.15	0.25	–										
WAPP (W)	–0.06	0.81	0.73	0.66	0.78	0.57	0.02	–									
WAMP (W)	–0.18	0.78	0.74	0.62	0.76	0.53	0.04	0.96	–								
WRPP ($W \times kg^{-1}$)	–0.03	–0.07	0.02	–0.03	–0.07	0.20	0.15	0.47	0.42	–							
WRMP ($W \times kg^{-1}$)	–0.26	–0.28	–0.11	–0.24	–0.26	0.02	0.20	0.18	0.29	0.81	–						
VJH (cm)	0.13	–0.23	–0.18	–0.17	–0.22	0.08	0.27	–0.08	–0.06	0.49	0.57	–					
VJPP (W)	0.11	0.91	0.79	0.73	0.89	0.63	0.03	0.78	0.77	0.14	–0.04	0.19	–				
RSS TLS-F (s)	0.28	0.50	0.46	0.34	0.50	–0.22	–0.05	0.02	0.01	–0.65	–0.66	–0.24	0.40	–			
RSS TLS-Avg (s)	0.31	0.50	0.43	0.22	0.55	–0.39	–0.23	0.06	0.03	–0.53	–0.60	–0.18	0.43	0.59	–		
RSS TLS-Fi (s)	–0.08	0.56	0.58	0.32	0.59	–0.62	–0.23	0.56	0.53	0.27	0.10	0.14	0.62	0.01	0.44	–	
Plus/minus	0.10	0.03	0.07	–0.12	0.09	0.42	–0.05	0.04	0.01	0.27	0.23	0.32	0.17	–0.01	–0.03	0.47	–

Note: $r \geq 0.44$ are significant at $p<0.05$; $r \geq 0.56$ are significant at $p<0.01$;% FAT = fat free mass; HR = heart rate; WAPP = Wingate absolute peak power; WAMP = Wingate absolute mean power; WRPP = Wingate relative peak power; WRMP = Wingate relative mean power; VJH = Vertical Jump height; VJPP = Vertical Jump peak power; RSS TLS-F = Repeated-Skate Sprint – time of the fastest total length skate 89 m (s); RSS TLS-Avg = Repeated-Skate Sprint – average time of the total length skate 6x89 m (s); RSS TLS-FI = Repeated-Skate Sprint – fatigue index calculated from the times recorded for subsequent TLS.

Discussion

This study aimed to identify the relationships of the results of the physiological and anthropometric tests and special on-ice fitness tests with individual player performance indicators (+/– score) during matches of the Poland men's national ice hockey team played during the U18 Ice Hockey World Championship. The main finding was that the +/– score was significantly correlated only with fatigue index calculated from the repeated-skate sprint (r=–0.62). However, it came as a great surprise to us, that there is no significant relationship between the $\dot{V}O_2max$ and the+/– score (r=0.42, n.s.). Green et al. (2006) have shown, in the course of their research, that the $\dot{V}O_2max$ is to be a significant predictor of performance. The difference in findings may be reflected in the outcome measure because +/– score is highly dependent on goalie ability as only goals impact the score. Scoring chances, on the other hand, is not directly impacted by goalie play (Peyer et al., 2011).

Ice hockey is characterized by multiple periods of high-intensity exercise interspersed with recovery periods. Energy for high-intensity exercise of this duration is supplied by anaerobic metabolism. Recovery from high-intensity exercise is thought to correlate with restoration of these metabolites to normal levels where the aerobic system may be of prime importance in this recovery process (Carey, Drake, Pliego, & Raymond, 2007). Taking into account the fact, that some researchers have shown there to be a relationship between the $\dot{V}O_2max$, and the fatigue index calculated from the repeated-skate sprint (r=–0.62), in the course of this study, the statistically significant relationship between the fatigue index calculated from the repeated-skate sprint test, and the absolute +/– score (r=0.47, p<0.05). The relationships between $\dot{V}O_2max$ and the FI for repeated sprints found in this studies seem to indicate that aerobic processes play a role in the recovery of energy substrates, which are necessary to exercise at high intensity (Stanula et al., 2014). There are many mechanisms that can explain this results. Most of all, high aerobic power increases the ability to recover from repeated bouts of anaerobic power, and probably decreases lactate concentrations in response to higher LA utilization in slow twitch muscle fibres (Tesch & Wright, 1983; Tomlin & Wenger, 2001).

Despite it being demonstrated in numerous research that there was a relationship among the vertical jump and on-ice maximum skating speed and acceleration time (Behm et al., 2005; Bracko & George, 2001; Farlinger, Kruisselbrink, & Fowles, 2007b), in this study there was no noted relationship among the vertical jump test results, the lower limb power attained in the Wingate test, and the+/– score. The causes of this state of affairs are difficult to explain. It is, however, to be emphasized that the participants of the study are at the threshold of their professional careers as hockey players. Some psycho-physiological characteristics, are not yet fully developed at their age. Besides, the Polish National Hockey Team is not among the best in the world. The adopted +/– evaluation system, on principle, gives better notes to the teams with a higher goal-scoring potential. That is why, individual results, depend, to a great extent on the level of training of the opponent team. This is, thus, one of the key factors proving that ice hockey is a very complex team game, the final result of which depends on various factors (Roczniok, Stanula, Maszczyk, et al., 2016).

There are some limitations considerations in this study. The findings are somewhat limited by the small sample size, which was inherently limited by the fact that we examined only 1 team which participated in 1 championships. Future studies should include larger samples, longer periods of observations and when possible, more sensitive outcome measures.

Conclusions

The results of this study suggest that game performance as indicated by the +/– score can be predicted by the fatigue index calculated from the repeated-skate sprint test. The results of the anthropometric measurements and body composition, as well as those of lower limb power tests, have not shown a significant influence upon the player performance as measured by the +/– system evaluation.

References

Behm, D. G., Wahl, M. J., Button, D. C., Power, K. E., & Anderson, K. G. (2005). Relationship between hockey skating speed and selected performance measures. *Journal of Strength and Conditioning Research*, *19* (2), 326–331.

Bishop, D., Lawrence, S., & Spencer, M. (2003). Predictors of repeated-sprint ability in elite female hockey players. *Journal of Science and Medicine in Sport, 6* (2), 199–209.

Bracko, M. R., & George, J. D. (2001). Prediction of ice skating performance with off-ice testing in women's ice hockey players. *Journal of Strength and Conditioning Research*, *15* (1), 116–122.

Buchheit, M., Lefebvre, B., Laursen, P. B., & Ahmaidi, S. (2011). Reliability, usefulness, and validity of the 30-15 Intermittent Ice Test in young elite ice hockey players. *Journal of Strength and Conditioning Research, 25* (5), 1457–1464.

Burr, J. F., Jamnik, R. K., Baker, J., Macpherson, A., Gledhill, N., & McGuire, E. J. (2008). Relationship of physical fitness test results and hockey playing potential in elite-level ice hockey players. *Journal of Strength and Conditioning Research, 22* (5), 1535–1543.

Carey, D. G., Drake, M. M., Pliego, G. J., & Raymond, R. L. (2007). Do hockey players need aerobic fitness? Relation between VO2max and fatigue during high-intensity intermittent ice skating. *Journal of Strength and Conditioning Research, 21* (3), 963–966.

Davis, J. A. (2006). Direct determination of aerobic power. In P. J. Maud & C. Foster (Eds.) (2nd ed., pp. 9–18). Champaign, IL: Human Kinetics.

Diakoumis, K., & Bracko, M. R. (1998). Prediction Of Skating Performance With Off-ice

Testing In Deaf Ice Hockey Players. *Medicine & Science in Sports & Exercise*, *30* (5), 272.

Durocher, J. J., Leetun, D. T., & Carter, J. R. (2008). Sport-specific assessment of lactate threshold and aerobic capacity throughout a collegiate hockey season. *Applied Physiology, Nutrition, and Metabolism = Physiologie Appliquee, Nutrition et Metabolisme*, *33* (6), 1165–1171.

Farlinger, C. M., Kruisselbrink, L. D., & Fowles, J. R. (2007a). Relationships to skating performance in competitive hockey players. *Journal of Strength and Conditioning Research*, *21* (3), 915–922.

Farlinger, C. M., Kruisselbrink, L. D., & Fowles, J. R. (2007b). Relationships to skating performance in competitive hockey players. *Journal of Strength and Conditioning Research*, *21* (3), 915–922.

Green, M. R., Pivarnik, J. M., Carrier, D. P., & Womack, C. J. (2006). Relationship between physiological profiles and on-ice performance of a National Collegiate Athletic Association Division I hockey team. *Journal of Strength and Conditioning Research*, *20* (1), 43–46.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2010). *Exercise physiology: nutrition, energy, and human performance* (7th ed.). Baltimore, MD: Lippincott Williams & Wilkins.

Montgomery, D. L. (1988). Physiology of Ice Hockey. *Sports Medicine*, *5* (2), 99–126.

Peyer, K. L., Pivarnik, J. M., Eisenmann, J. C., & Vorkapich, M. (2011). Physiological characteristics of National Collegiate Athletic Association Division I ice hockey players and their relation to game performance. *Journal of Strength and Conditioning Research*, *25* (5), 1183–1192.

Reed, A., Hansen, H., Cotton, C., Gauthier, R., Jette, M., Thoden, J., & Wenger, H. (1980). Development and validation of an on-ice hockey fitness test [abstract]. *Canadian Journal of Applied Sport Sciences*, (5), 245.

Roczniok, R., Stanula, A., Gabryś, T., Szmatlan-Gabryś, U., Gołaś, A., & Stastny, P. (2016). Physical fitness and performance of polish ice-hockey players competing at different sports levels. *Journal of Human Kinetics*, *50* (2), 201–208.

Roczniok, R., Stanula, A., Maszczyk, A., Mostowik, A., Kowalczyk, M., & Zając, A. (2016). Physiological, physical and on-ice performance criteria for selection of elite ice hockey teams. *Biology of Sport*, *33* (1), 43–48.

Stanula, A., & Roczniok, R. (2014). Game Intensity Analysis of Elite Adolescent Ice Hockey Players. *Journal of Human Kinetics*, *44* (1), 211–221.

Stanula, A., Roczniok, R., Maszczyk, A., Pietraszewski, P., & Zając, A. (2014). The role of aerobic capacity in high-intensity intermittent efforts in ice-hockey. *Biology of Sport*, *31* (3), 193–195.

Tesch, P. A., & Wright, J. E. (1983). Recovery from short term intense exercise: its relation to capillary supply and blood lactate concentration. *European Journal of Applied Physiology and Occupational Physiology*, *52* (1), 98–103.

Tomlin, D. L., & Wenger, H. A. (2001). The relationship between aerobic fitness and recovery from high intensity intermittent exercise. *Sports Medicine (Auckland, N .Z.)*, *31* (1), 1–11.

Vescovi, J. D., Murray, T. M., Fiala, K. A., & VanHeest, J. L. (2006). Off-ice performance and draft status of elite ice hockey players. *International Journal of Sports Physiology and Performance*, *1* (3), 207–221.