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THE PREDICTIVE VALUE OF ON-ICE SPECIAL TESTS IN RELATION TO VARIOUS INDEXES OF AEROBIC AND ANAEROBIC CAPACITY IN ICE HOCKEY PLAYERS

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ABSTRACT
Purpose. The main goal of this study was to determine the predictive value of the indexes of aerobic and anaerobic endurance in relation to specific on-ice tests performed by hockey players that focus on strength, power, speed as well as speed and strength endurance. **Methods.** Ice hockey players, who were members of the U20 (under 20 years of age) Polish National Ice Hockey Team, were selected from the Athletic School in Sosnowiec, Poland. Parameters that determine anaerobic and aerobic capacity were evaluated and a special physical fitness assessment was made based on a battery of ice-hockey specific tests. The degree and direction of correlations between the individual parameters of anaerobic and aerobic endurance and the special physical fitness test were calculated. **Results.** The obtained results found significant correlations between maximal power obtained from the Wingate test and certain aspects of the special physical fitness test, specifically the 6 × 9 turns, 6 × 9 stops and 6 × 30 m endurance tests. Significant correlations of the above-mentioned special physical fitness tests were also observed with the aerobic capacity parameter, VO_2max. **Conclusions.** The obtained results could be considerably useful in training, as well as providing much more information on athletes which can then be suited for more personalized forms of training.

Key words: aerobic capacity, Wingate test, special physical fitness tests, ice hockey

Introduction

Scoring takes great technique and accuracy, but it also requires an aggressive attitude, good decision making and opportunities resulting from solid team play. Historically, coaching intervention has been based on subjective observations of athletes. However, several studies have shown that such observations are not only unreliable but also inaccurate. Although the benefits of feedback and the knowledge of results are well accepted, the problems of highlighting memory and observational difficulties result in the accuracy of coaching feedback being very limited. Nowadays there is a necessity to apply statistical analyses in sport sciences.

Hockey is widely considered to be an aerobic activity accentuated with several repeated bouts of anaerobic exercise [1]. A longitudinal study by Cox et al. [2] gathered physiological data on over 170 players from the National Hockey League (NHL) from 1980 to 1991. Over this time period VO_2max was found to increase from an average of 54 ml/kg/min in 1980 to just over 62 ml/kg/min (N = 635) in 1991 in this group of studied players.

A similar longitudinal study by Montgomery [3] looked at physiological data, including size, strength and aerobic fitness of the Montreal Canadiens of the NHL, beginning in 1917. Compared to players from the 1920s and 1930s, today's players were an average of 17 kg heavier and 10 cm taller with an average BMI increase of 2.3 kg · m^{-1}. Aerobic fitness (VO_2max) was also found to increase from 54.6 to 59.2 ml/kg/min between 1992 and 2003, but the variability of the data made it impossible to determine if this increase was significant.

Green et al. [4] conducted a study on an NCAA Division I hockey team and how their physiological profiles, including VO_2max, blood lactate, and percent body fat, related to their performance. Using a discontinuous protocol in which blood lactate was measured between three-minute stages of treadmill running, blood lactate levels averaged 8.9 ± 2.1 mmols · L^{-1} at the end of the fourth stage, the last stage completed by each of the subjects. This stage was tested at 12.9 km · h^{-1} and a seven-percent grade on the treadmill. Aerobic fitness (VO_2max) accounted for 17% of the variance in performance, which was based on overall scoring chances while a particular player was on the ice. It was concluded that only VO_2max significantly predicted performance.

While some previous literature suggests that increased aerobic capacity would benefit performance in sports such as ice hockey, which is a game of high intensity interval bouts of exercise, there is literature suggesting otherwise.

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Each year the National Hockey League (NHL) Entry Draft Combine tests approximately 110 to 120 players to determine a variety of fitness measures that may affect the order of draft selection [5]. Both anaerobic and aerobic capacities are currently measured during cycle ergometer protocols [5, 6]. Anaerobic and aerobic metabolism is often unrecognized in a traditionally known anaerobic-based task such as ice hockey. As a result, aerobic power has only been examined over the past 35 years in ice hockey [7–9] based on physiological data involving, for example, portable gas analysis [7], cycle ergometry [10] and running treadmills [11].

It has been suggested in previous training literature that to be successful at an elite level in ice hockey, it is necessary to maintain a highly developed aerobic system with a relative aerobic capacity of approximately 50–60 mL/kg/min [12]. This is consistent with recently published aerobic power values in well-trained elite-level hockey players [4, 13, 14].

Therefore, measuring anaerobic endurance and anaerobic power is of great importance for elite hockey players based on which training has a greater influence on the physical performance of hockey players. The development of an elite hockey training program should focus on improving each of the fitness components (i.e. flexibility, strength etc.) and include some on-ice short intervals, multi-directional directional skating as well as puck, technical skating and movement skills. These three phases need to be further broken down into macro-cycles of 2–6 weeks and with micro-cycles of weekly or daily lesson plans.

Training for hockey players must be developed with a thorough understanding of the game itself. Players often go beyond their understanding and knowledge of the physiology of hockey leading to overtraining, injury and a decrease in performance. The sport of ice hockey is physically demanding at the elite level, requiring trained aerobic and anaerobic energy systems. The sport demands not only significant glycolytic activity, which occurs during bursts of intense muscular activity, but also aerobic power and endurance [11]. Appropriate training and maintenance of fitness levels may help prevent hockey injuries and the onset of premature fatigue [2].

Studies on other sports have shown that physiological variables can be related to individual performance [15–17]. Therefore, the goal of the present study was to determine the predictive value of the indexes of control of anaerobic and aerobic endurance in relation to specific tests performed by ice hockey-players in terms of their strength, speed, power, as well as speed and strength endurance. The objectives of this research rested in posing the following questions:

1. Are there any significant correlations between the parameters of anaerobic capacity and special physical fitness tests?
2. Are there any significant correlations between the parameters of aerobic capacity and special physical fitness tests?
3. What is the strength and direction of these relationships?

Material and methods

In order to verify the above-mentioned objectives, investigation was carried out in September 2009, just before the Ice Hockey U20 World Championships, on 21 hockey players aged 19–20 years from the Athletic School in Sosnowiec, who were members of the U20 (under 20 years of age) Polish National Ice Hockey Team. Due to the necessity in obtaining information on the level of aerobic power among the studied group of hockey players, exercise with unequally rising intensity was performed on a Cyclus 2 bicycle ergometer (RBC Elektronik-Automation GmbH, Germany). The exercise test was based on seven exercise stages, with the first three stages taking two minutes each using a load of 1.5, 2.25 and then 3 W/kg. The remaining four stages took one minute each where the load was increased to 3.5, 4, 4.5 and then 5 W/kg. Some modification in relation to the exercise test used for testing NHL competitors was introduced. Constant values of power were replaced with load values that correspond to body mass. This modification was based on the considerable differentiation of the studied group in terms of body mass reaching 30 kg, which accounted for 30–50% of intergroup differentiation. The assumptions of the test predicted that the subjects would reach anaerobic threshold (AT) in the first part of the exercise and the response of the circulatory and respiratory systems would correspond to the intensity of VO_2max. A fundamental advantage of taking this modification into consideration in an exercise test is due to the typical nature of performance in hockey (intervals with frequently changing intensity) and high body mass, which limits the ability to continue activity for a longer period of time.

Blood samples were taken during the exercise in order to determine the level of lactate concentration before exercise (LArest), after the 1st increase in load (LA1), at the end of the exercise (LAmax) and in the 4th (LA4) and 8th (LA8) minute of recovery.

After 24 h of rest, all of the subjects preformed the 30-secound Wingate test to determine anaerobic capacity on a Monark cycloergometer (Monark, Sweden). A 5-min warm-up was performed with a resistance of 50 W and pedal frequency of approximately 70 revolutions per minute. Next, the Wingate test was performed with the resistance of the cycloergometer adjusted to the athlete's body weight (9% of body mass). All of the athletes were instructed to cycle as quickly and powerfully as possible throughout the entire test's duration.

In addition to the above-mentioned tests, special physical fitness tests on ice were also carried out. A set of measurable hockey skills which provide information on speed and endurance were used, composed of the 30 m Forward Sprint, the 30 m Backward Sprint, 6 × 9 m Hockey Stops, 6 × 9 m Turns, and an Endurance Test (6 × 30 meters).

The measured variables, based on a method of direct participant observation, were then subjected to empirical and exploratory analyses. Descriptive statistics were calculated to include mean ± standard deviation (SD) and min and max values with all of the variables examined for normal distribution. Normality was confirmed using measures of kurtosis and skewness. In order to answer the research questions set out in this study, Pearson's linear correlation analysis was also carried out.

This study was approved by the Bioethics Committee of Scientific Research at the Academy of Physical Education in Katowice (Study No. 16/06). It was part of the framework of "The Multicriterion Optimization of Investigative Problems of Sports Training" project, headed by the Ministry of Science and Higher Education in Poland. The authors of this study declare no conflict of interest.

Results

The average values of the physiological variables and performance measurements taken in this study are presented in Table 1. Analysis of the obtained results on aerobic and anaerobic capacity revealed that they were similar to the results obtained by other researchers worldwide [3, 5, 18, 19].

Based on the analyses conducted on the measured variables (Tab. 2), significant negative correlations between the indexes of anaerobic capacity and the special physical fitness tests on ice were observed only between maximal power (measured in Watts per kilogram) and the variables: 6 × 9 m Stops, 6 × 9 m Turns, Endurance (6 × 30 m). Correlation was also observed between LA8' and the variables: 6 × 9 m Stops and 6 × 9 m Turns. In the case of other variables of anaerobic capacity, no statistically significant relationships with the special physical fitness tests on ice were observed.

In the case of relationships between the indexes of aerobic capacity and the special physical fitness test on ice (Tab. 3), significant negative correlations were observed between VO_2max with the variables: 6 × 9 m Stops and Endurance (6 × 30 m), correlation between HRmax and the 30 m Backward Sprint, correlation between LA1 and the variables: 30 m Sprint Forwards, 6 × 9 m Stops and Endurance (6 × 30 m), and correlation between LA4 and 6 × 9 m Stops. As a side note, LA4 was previously used as an indicator of aerobic endurance in Green's research [4]. Coaches may prefer players who are leaner and have a lower lactate at a given VO_2, which enables players to play at high intensity without fatigue. With regard to the other variables of aerobic capacity, no significant relationships with the special physical fitness tests on ice were found.

Table 1. Physiological and performance measurements

	Variables	Mean	SD	Min	Max
Special tests on ice	30 m Forward Sprint (s)	4.63	0.31	4.25	5.36
	30 m Backward Sprint (s)	5.66	0.55	4.98	7.29
	6 × 9 m Turns (s)	13.7	0.58	12.73	14.62
	6 × 9 m Stops (s)	13.29	0.56	12.45	14.38
	Endurance (6 × 30 m) (s)	33.03	1.16	31.9	36.58
Anaerobic Capacity	Pmax (W)	1030.83	93.3	814	1378.5
	Pmax (W/kg)	12.97	0.57	11.5	14.1
	LArest' (mmol/l)	2.02	0.82	1.01	3.66
	LA4' (mmol/l)	13.17	1.4	11.67	16.76
	LA8' (mmol/l)	13.77	1.03	11.69	15.81
Aerobic Capacity	VO_2max (ml/kg/min)	57.88	4.94	45	66
	HRmax (bpm)	186.69	9.16	170	203
	LArest (mmol/l)	2.18	0.61	1.39	3.39
	LA1 (mmol/l)	4.43	1.46	2.53	7.87
	LAmax (mmol/l)	10.29	1.29	7.17	12.17
	LA4 (mmol/l)	10.97	1.58	6.79	12.89
	LA8 (mmol/l)	10.06	1.85	5.32	13.75

Pmax (W) – Absolute peak power, Pmax (W/kg) – Relative peak power, LArest' (mmol/l) – Lactate concentration before the Wingate test, LA4' (mmol/l) – Lactate in the 4th minute of recovery in the Wingate test, LA8' (mmol/l) – Lactate in the 8th minute of recovery in the Wingate test, VO_2max (ml/kg/min) – Relative VO_2max, HRmax (bpm) – Max heart rate, LArest (mmol/l) – Lactate concentration before the VO_2max test, LA1 (mmol/l) – Lactate concentration after the 1st stage of load increase in the VO_2max test, LAmax (mmol/l) – Lactate concentration after the VO_2max test, LA4 (mmol/l) – Lactate concentration in the 4th minute of recovery in the VO_2max test, LA8 (mmol/l) – Lactate in the 8th minute of recovery in the VO_2max test

Table 2. Correlations between the indexes of anaerobic capacity and the special physical fitness tests on ice

	30 m Forward Sprint (s)	30 m Backward Sprint (s)	6 × 9 m Turns (s)	6 × 9 m Stops (s)	Endurance (6 × 30 m) (s)
Pmax (W)	–0.13	0.22	–0.42	–0.26	–0.27
Pmax (W/kg)	–0.20	0.06	–0.64*	–0.58*	–0.57*
LArest' (mmol/l)	–0.15	0.02	–0.27	0.03	–0.14
LA 4' (mmol/l)	–0.24	–0.18	–0.08	–0.26	–0.22
LA 8' (mmol/l)	0.10	–0.39	–0.48	–0.62*	–0.34

* significant correlations $p \leq 0.05$

Pmax (W) – Absolute peak power, Pmax (W/kg) – Relative peak power, LArest' (mmol/l) – Lactate concentration before the Wingate test, LA4' (mmol/l) – Lactate in the 4th minute of recovery in the Wingate test, LA8' (mmol/l) – Lactate in the 8th minute of recovery in the Wingate test

Discussion

The physiological profiles of elite hockey teams reveal the importance of aerobic endurance, anaerobic power and endurance, muscular strength and skating speed. Although field hockey is played on a similar sized course with the same number of players and for a similar

Table 3. Correlations between the indexes of aerobic capacity and the special physical fitness test on ice

	30 m Forward Sprint (s)	30 m Backward Sprint (s)	6 × 9 m Turns (s)	6 × 9 m Stops (s)	Endurance (6 × 30 m) (s)
VO_2max (ml/kg/min)	–0.46	–0.32	–0.49	–0.68*	–0.62*
HRmax (bpm)	0.15	0.23	–0.10	0.13	0.27
LArest (mmol/l)	0.11	–0.39	–0.21	–0.32	–0.45
LA 1 (mmol/l)	0.60*	0.39	0.31	0.61*	0.66*
LAmax (mmol/l)	0.19	–0.02	0.19	–0.06	0.32
LA 4 (mmol/l)	–0.12	–0.37	–0.15	–0.58*	–0.12
LA 8 (mmol/l)	–0.02	–0.34	–0.06	–0.47	–0.05

* significant correlations $p \leq 0.05$

VO_2max (ml/kg/min) – Relative VO_2max, HRmax (bpm) – Max heart rate, LArest (mmol/l) – Lactate concentration before the VO_2max test, LA1 (mmol/l) – Lactate concentration after the 1st stage of load increase in the VO_2max test, LAmax (mmol/l) – Lactate concentration after the VO_2max test, LA4 (mmol/l) – Lactate concentration in the 4th minute of recovery in the VO_2max test, LA8 (mmol/l) – Lactate in the 8th minute of recovery in the VO_2max test

duration, it is physiologically closer to soccer and does not allow for cross-sectional comparison. While game play is similarly intermittent in field hockey, players must perform continuously for 70 minutes with just one 5–10 minute interval. This places a high demand on the aerobic system and good aerobic endurance is required to support repetitive bouts of high intensity exercise [11].

For elite ice hockey players, anaerobic power and anaerobic endurance is of critical importance [2], making strength an important part of a hockey training program. Although players are not required to meet certain physical challenges (when compared to other multi-sprint sports), power is required for acceleration, to maintain speed and for quick direction changes. Upper body strength allows players to shoot more powerfully and pass over a greater range of distance.

All in all, the bio-energetic demands of the sport require heavy bouts of high-intensity whole-body exercise characterized by high-speed explosive skating and sudden changes of direction, coordinated with spontaneous bursts of muscular strength and power [12]. In an average hockey game, there are typically 5–7 bursts of maximal skating per shift, leading to an average of 4–6 min/game of high-intensity bouts of maximal effort [4], and an average heart rate intensity of 70–90% of maximum heart rate (HRmax). Although intermittent, the game of ice hockey does require approximately 15–20 min of both aerobic and anaerobic energy expenditure per game at a competitive level [14] and repeated back-to-back sprints make speed and tolerance changes in acid-base balance an important characteristic of elite players [15].

In elite level hockey, there has been a long-standing debate among scouts, coaches, strength/conditioning specialists and physiologists as to the relative utility of on-ice tests for aerobic and anaerobic power prediction. Nonetheless, having access to ice-specific special physical fitness tests, which are good predictors of the most important indexes of aerobic and anaerobic capacity, might minimize the number of expensive off-ice tests and minimize disturbance to training cycles, particularly during the competitive season or play-offs.

The obtained results allow us to identify the significant relationships between the indexes of anaerobic and aerobic capacity and these special physical fitness tests on ice. The athletes who were faster in 6 × 9 m Stops, 6 × 9 m Turns, Endurance (6 × 30 m) tests achieved higher power values in the Wingate test and showed higher VO_2max. Significant negative relationships were also found between the level of lactate after the Wingate test and the variables 6 × 9 m Stops and 6 × 9 m Turns. These results allow for the conclusion that higher degrees of acidification correspond to shorter trial times. Similar results were obtained when analysing the results of negative correlation between the acidification in the aerobic capacity test in the 4th and 8th minute and the variable 6 × 9 m Turns. In contrast, positive correlation was observed for the level of acidification measured after the first stage of load increase in LA1 and between the 30 m Sprint Forwards, 6 × 9 m Turns, and Endurance (6 × 30 m) variables. The higher acidification showed by the tested athletes in the first part of the aerobic capacity test corresponded to poorer results obtained in the special physical fitness test on ice.

The results presented here are also confirmed by those reported by other authors [20], which state that aerobic and anaerobic capacity are important physiological characteristics for ice hockey players [2, 21]. Because of the relatively short but intense work intervals found in an ice hockey game (from 30 to 60 seconds), the ability to produce anaerobic energy might dictate performance within a given shift when playing on ice [2, 21]. Although a variety of on-ice skating tests have been developed, the Wingate test on a cycle ergometer (from 15 to 45 seconds) remains the most commonly used test for assessing anaerobic power and capacity in hockey players [22]. Even if such short shifts predominate in ice hockey, the physiological demands are not limited to anaerobic pathways. In fact, aerobic capacity is responsible for the recovery from such high-intensity intermittent exercise and, therefore, acts as a buffer against fatigue and minimizes the attenuation of power output during subsequent shifts [20].

Conclusion

Ice hockey is a physically demanding contact sport involving repeated bouts of high intensive effort, with players' shifts lasting from 30 to 80 seconds [23–25].

Given the anaerobic nature of these sprint-based phases (69% anaerobic glycolysis) and the aerobic recovery (31% aerobic metabolism) between shifts and periods, as well as the physicality of the game, success at the elite level requires players to develop a well-rounded fitness level that includes anaerobic sprint ability, a strong aerobic endurance base, and high levels of muscular strength, power and endurance [2, 23, 24, 26].

The athletes who performed better in the 6 × 9 m Stops, 6 × 9 m Turns and Endurance (6 × 30 m) tests achieved higher power values in the Wingate test as well as showing higher VO_2max. Therefore, the most important findings of this study suggest that the best predictors of aerobic and anaerobic capacity are the 6 × 9 m Stops, 6 × 9 m Turns and Endurance (6 × 30 m) tests. Such knowledge might be considerably useful in the frequent control of training process, as well as providing much more information on athletes which can then be suited for more personalized forms of training.

References

1. Carey D.G., Drake M.M., Pliego G.J., Raymond R.L., Do hockey players need aerobic fitness? Relation between VO_2max and fatigue during high-intensity intermittent ice skating. *J Strength Cond Res*, 2007, 21 (3), 963–966, doi: 10.1519/R-18881.1.
2. Cox M.H., Miles D.S., Verde T.J., Rhodes E.C., Applied physiology of ice hockey. *Sports Med*, 1995, 19 (3), 184–201.
3. Montgomery D.L., Physiological profile of professional hockey players: A longitudinal comparision. *Appl Physiol Nutr Metab*, 2006, 31 (3), 181–185, doi: 10.1139/ H06-012.
4. Green M.R., Pivarnik J.M., Carrier D.P., Womack C.J., Relationship between physiological profiles and on-ice performance of a National Collegiate Athletic Association Division I hockey team. *J Strength Cond Res*, 2006, 20 (1), 43–46, doi: 10.1519/ R-17985.1.
5. Burr J.F., Jamnik R.K., Baker J., Macpherson A., Gledhill N., McGuire E.J., Relationship of physical fitness test results and hockey playing potential in elite-level ice hockey players. *J Strength Cond Res*, 2008, 22 (5), 1535–1543, doi: 10.1519/JSC.0b013e318181ac20.
6. Gledhill N., Jamnik V., Detailed assessment protocols for NHL entry draft players. York University, Toronto 2007.
7. Nobes K.J., Montgomery D.L., Pearsall D.J., Turcotte R.A., Levebvre R., Whittom F., A comparison of skating economy on ice and on the skating treadmill. *Can J Appl Physiol*, 2003, 28 (1), 1–11.
8. Leger L., Seliger V., Brassard L., Comparisons among VO_2max values for hockey players and runners. *Can J Appl Sport Sci*, 1979, 4 (1), 18–21.
9. Lariviere G., Lavallee H., Shephard R.J., A simple skating test for ice hockey players. *Can J Appl Sport Sci*, 1976, 1, 223–228.
10. Cox M.H., Miles D.S., Verde T.J., Levine A.R., Physical and physiological characteristics of NHL players over the last decade. *Med Sci Sports Exerc*, 1993, 17, 332–338.
11. Cox M.H., Rhodes E.C., Thomas S., Quinney A., Fitness testing of elite hockey players. *Can Athl Ther J*, 1988, 1, 6–13.
12. Twist P., Rhodes T., The bioenergetic and physiological demands of ice hockey. *National Strength and Conditioning Association Journal*, 1993, 15 (5), 68–70.
13. Montgomery D.L., Physiology of ice hockey. In: Garrett W.E., Kirkendall D.T. (eds.), Exercise and sport science. Lippincott, Williams & Wilkins, Philadelphia 2000, 815–828.
14. Hoff J., Kemi O.J., Helgerud J., Strength and endurance differences between elite and junior elite ice hockey players. The importance of allometric scaling. *Int J Sports Med*, 2005, 26 (7), 537–541, doi: 10.1055/s-2004-821328.
15. Helgerud J., Engen L., Wisløff U., Hoff J., Aerobic endurance training improves soccer performance. *Med Sci Sports Exerc*, 2001, 33, 1925–1931.
16. Mahler D.A., Parker H.W., Andresen D.C., Physiologic changes in rowing performance associated with training in collegiate women rowers. *Int J Sports Med*, 1985, 6 (4), 229–233.
17. Norris S.R., Petersen S., Effects of endurance training on transient oxygen uptake responses in cyclists. *J Sports Sci*, 1998, 16 (8), 733–738, doi: 10.1080/026404198366362.
18. Vescovi J.D., Murray T.M., Fiala K.A., VanHeest J.L., Off-ice performance and draft status of elite ice hockey players. *Int J Sports Physiol Perform*, 2006, 1 (3), 207–221.
19. Quinney H.A., Dewart R., Game A., Snydmiller G., Warburton D., Bell G., A 26 year physiological description of a National Hockey League team. *Appl Physiol Nutr Metab*, 2008, 33 (4), 753–760, doi: 10.1139/H08-051.
20. Glaister M., Multiple sprint work: physiological responses, mechanisms of fatigue and the influence of aerobic fitness. *Sports Med*, 2005, 35 (9), 757–777.
21. Montgomery D.L., Physiology of ice hockey. *Sports Med*, 1988, 5 (2), 99–126.
22. Ebben W.P., Carroll R.M., Simenz C.J., Strength and conditioning practices of National Hockey League strength and conditioning coaches. *J Strength Cond Res*, 2004, 18 (4), 889–897, doi: 10.1519/14133.1.
23. Green D.J., Maiorana A., O'Driscoll G., Taylor R., Effect of exercise training on endothelium-derived nitric oxide function in humans. *J Physiol*, 2004, 561, 1–25, doi: 10.1113/jphysiol.2004.068197.
24. Lau S., Berg K., Latin R.W., Noble J., Comparison of active and passive recovery of blood lactate and subsequent performance of repeated work bouts in ice hockey players. *J Strength Cond Res*, 2001, 15 (3), 367–371.
25. Mascaro T., Seaver B.L., Swanson L., Prediction of skating speed with off-ice testing in professional hockey players. Paper presented at: Sports Physical Therapy Section Team Concept Meeting, New Orleans, 1991.
26. Seliger V., Kostka V., Grusová D., Kovác J., Machovcová J., Pauer M., Pribylová A., Urbánková R., Energy expenditure and physical fitness of ice-hockey players. *Int Z Angew Physiol*, 1972, 30 (4), 283–291.

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