Original Article

Assessment of physical parameters and age of current Canadian-American National Hockey League (NHL) ice hockey players in relation to game position and player success

MARTIN SIGMUND¹, PETR KUTÁČ², MICHAL KUDLÁČEK³, JANA KVINTOVÁ⁴, STEVEN KOHN⁵, DAGMAR SIGMUNDOVÁ⁶

^{1,3,6}Faculty of Physical Culture, Palacký University, Olomouc, CZECH REPUBLIC.

²Human Motion Diagnostics Center, University of Ostrava, Ostrava, CZECH REPUBLIC.

⁴Faculty of Education, Palacký University, Olomouc, CZECH REPUBLIC.

⁵College of Education and Human Services, Valdosta State University, Valdosta, GA, UNITED STATES OF AMERICA.

Published online: October 30, 2016

(Accepted for publication September 30, 2016)

DOI:10.7752/jpes.2016.s2166

Abstract:

In the present paper we analysed this issue in elite ice hockey players in the Canadian-American NHL. The objective of the study was an analysis of physical parameters and age of current ice hockey players in the National Hockey League in relation to various gaming positions and player success. The data were obtained from a total of 974 players and divided according to gaming positions [Goalkeepers ($N = 92$); Defenders ($N = 308$); Forwards ($N = 574$)]. Statistical quantities were calculated for all variables; normality of distribution was verified. Parametric as well as non-parametric statistical tests were applied. The Shapiro-Wilk test was used to assess normality. A multiple comparison was performed using the Kruskal-Wallis test. The associations between physical parameters and player success were estimated using the Spearman's correlation. The level of statistical significance was tested at a level of $\alpha \leq 0.05$; $\alpha \leq 0.01$. Statistical results processing was performed using the Statistica programme vers. 12.0. A statistical analysis did not confirm significant associations between the parameters of body height, body weight and BMI on the one hand, and the monitored objective indicators of player success of goalkeepers, defenders and forwards on the other hand. On the contrary, the study indicated significant associations between the basic physical parameters and negative player behaviour represented by increased number of penalty minutes, especially for defenders and forwards. A major determinant of player performance seems to be the age factor. It was revealed that increasing player age corresponds with player success in many monitored parameters in all gaming positions. The findings help clarify the partial factors affecting the overall performance in ice hockey players with regard to their gaming positions in the NHL.

Key Words: man, elite sport, NHL, achievement.

Introduction

To achieve the highest performance level in sport requires significant development of motor abilities and skills with an overall high level of development of physical fitness. This is associated with optimum development of somatic parameters, which represent a significant part of the structure of top level sports performance (McArdle, Katch, & Katch, 2007; Perič & Dovalil, 2010). Numerous studies carried out by sports anthropologists result in defining specific somatic parameters and in determining specific morphological types relating to a particular sport sector (Blanchard, 1995; Bolin & Granskog, 2003; Malina, Bouchard, & Or, 2004; Norton & Olds 2001; Vescovi, Murray, & Vanheest, 2006). Somatic parameters represent an important part of ice hockey player performance (Barzilay, 2002; Kutáč & Sigmund, 2015; Montgomery, 2006).

Body height and body weight are the basic somatic indicators that primarily inform about possible dispositions of elite athletes considering their specialization and gaming position. In today's top level sport, in our case ice hockey, it seems unrealistic to succeed without an optimum development of somatic performance factors. Their development is influenced by genetic predisposition combined with controlled training. Some players who meet the current high requirements have been involved in a special training programme since junior years (MacLean, 2008; Manners, 2004; Palmer & Spriet, 2008). Assessment of the development of somatic parameters is an integral part of recruitment and selection of young players for the Canadian-American NHL (Gledhill & Jamnik, 2007). At present, especially the following parameters are monitored in selecting NHL players: Standing Height, Wingspan, Body Weight and Body Composition (NHL Draft Combine Testing, 2015). The morphological and physiological level of development represents an important predictive factor of performance in young ice hockey players (Roczniok et al., 2013; Skowronek, Socha, Roczniok, & Socha, 2013; Tarter, 2009). Assessment of somatic and morphological parameters is also included in NBA or NFL draft (NBA, 2016; NFL, 2016). Currently, the variables affecting player performance are assessed not only in male ice

hockey players; women's performance determinants are regularly assessed as well (Geithner, Lee, & Bracko, 2006; Szmatlan-Gabrys, Stanula, Gabrys, & Ozimek, 2014).

The present study builds on a previous study analysing the current level of development of basic somatic parameters in NHL players with regard to player roles and gaming positions (Sigmund, Kohn & Sigmundová, 2016). It was observed that the current average value of body height in NHL ice hockey players was 186 cm, average body weight was 92 kg and BMI value was 26.5 kg/m². In terms of gaming positions we revealed the highest values of body height in ice hockey goalkeepers (188.3±4.4 cm), followed by defenders and forwards. The highest values of body weight were observed in ice hockey defenders (93.0±6.5 kg). Body weight of goalkeepers and forwards appears almost identical. A detailed analysis of ice hockey forwards suggested the highest values of body height in left wing forwards, we also observed a trend of higher values of body weight in right and left wing forwards in comparison with lower values of centre forwards (Sigmund, Kohn, & Sigmundová, 2016). The study mentioned above did not assess the associations between the monitored somatic characteristics, gaming positions and player success. For this reason we build on this study and present an assessment of associations between these variables.

The aim of the present study is to analyse the level of development of basic somatic characteristics and age of current ice hockey players in the Canadian-American National Hockey League (NHL) with respect to player success of goalkeepers, defenders and forwards.

Material & methods

Subjects

The present study analyses available basic morphological data of current players in the Canadian-American NHL; the survey is of a descriptive-comparative nature (Thomas, Nelson & Silverman, 2011). The observed values of the monitored physical parameters (Body Height; Body Weight, BMI), age, and objective indicators of player success in adult ice hockey players in the Canadian-American National Hockey League (NHL) were analysed in April 2016. A total of 974 personal player cards were processed (100% male). The present data represent the absolute collection of the monitored values of world class professional ice hockey players in the NHL. The average body height (cm), body weight (kg) and BMI (kg/m²) of the monitored NHL players (2015/2016 season) was 185.8 cm (SD = 5.30), 90.6 kg (SD = 6.95) and 26.2 kg/m² (SD = 1.57). The average age of the monitored NHL players was 26.5 years (SD = 4.49; range 18–44 years). In addition, individual values of the monitored parameters were divided into subsets according to the respective gaming position (Goalkeepers, *N* = 92; Defenders, *N* = 308; Forwards, *N* = 574). The average body height, body weight, BMI and age of the monitored NHL goalkeepers was 188.2 cm (SD = 4.32), 89.6 kg (SD = 6.29), 26.2 kg/m² (SD = 1.67) and 27.4 years (SD = 4.38). The average body height, body weight, BMI and age of the monitored NHL defenders was 187.2 cm (SD = 5.20), 92.5 kg (SD = 7.28), 26.4 kg/m² (SD = 1.64) and 26.5 years (SD = 4.50). The average body height, body weight, BMI and age of the monitored NHL forwards was 184.6 cm (SD = 5.19), 89.7 kg (SD = 6.66), 26.3 kg/m² (SD = 1.46) and 26.4 years (SD = 4.49). The analysed data are based on relevant sources of all current organisations active in the Canadian-American NHL (*N* = 30). The analytical survey included players of various nationalities, especially from Canada (50%), USA (25%), Sweden (8%), Russia (4%), Czech Republic (4%), Finland (4%), Slovakia (1%) and others (4%) (QuantHockey, 2015).

To convert the values to metric units we used the data from a conversion table (Malina, Bouchard, & Bar-Or, 2004). In our case we worked with the following conversions: 1 foot = 30.48 cm; 1 inch = 2.54 cm; 1 pound = 0.454 kg.

Statistical analysis

Statistical quantities were calculated for all variables; normality of distribution was verified. Parametric as well as non-parametric statistical tests were applied. The Shapiro-Wilk test was used to assess normality. A multiple comparison was performed using the Kruskal-Wallis test. The associations between physical parameters and player success were estimated using the Spearman's correlation. The level of statistical significance was tested at a level of $\alpha \leq 0.05$; $\alpha \leq 0.01$. Statistical results processing was performed using the Statistica v. 12.0 programme (Statistica, Tulsa, USA).

Results

The results section presents the associations between body height, body weight, BMI and age, and gaming position (goalkeeper, defender, forward) and player success. The selected indicators of player performance/success fully corresponded with NHL indicators. The indicators of goalkeeper player success included goals against average, save percentage, games won, games lost, shutouts, play minutes and penalty minutes. For defenders and forwards, a different set of indicators was assessed than for goalkeepers. These were the indicators that inform about player effectiveness such as total points, goals scored, assists, penalty minutes, goals per games played, assists per games played and points per games played (QuantHockey, 2015).

In the case of NHL goalkeepers, no significant associations were observed between the values of basic somatic parameters and indicators of goalkeeper player success. Significant relationships were observed in

goalkeepers with respect to age. There was a significant negative correlation between age and save percentage (SV%). Significant associations were also observed between a higher age and games lost, play minutes and increased inclination to negative player behaviour represented by penalty minutes (Table 1).

Table 1. Spearman's correlation of body height, body weight and BMI with indicators of player success in current NHL goalkeepers

Goalkeepers	GAA	SV%	W	L	SO	Time	PIM
BH	-0.108	-0.121	0.080	0.004	-0.087	0.076	0.154
BW	-0.024	-0.015	0.185	0.095	-0.033	0.179	0.153
BMI	-0.074	-0.101	0.132	0.082	-0.028	0.133	0.054
AGE	0.195	-0.228*	0.277**	0.319**	0.131	0.333**	0.277**

Legend: BH – body height; BW – body weight; BMI – body mass index; GAA – goals against average; SV% – save percentage; W – games won; L – games lost; SO – shutouts; Time – play minutes; PIM – penalty minutes; * – statistical significance $p < 0.05$; ** – statistical significance $p < 0.01$

In ice hockey defenders, significant associations were observed between higher values of body height, body weight, BMI and age on the one hand and a higher number of penalty minutes on the other hand. The study also suggested a significantly negative association in defenders between body height and player productivity represented by individual points per game. Increasing age of ice hockey defenders was associated with higher player success represented by number of assists (Table 2).

Table 2. Spearman's correlation of body height, body weight and BMI with indicators of player success in current NHL defenders

Defenders	P	G	A	PIM	G/GP	A/GP	P/GP
BH	-0.092	-0.090	-0.085	0.189***	-0.120*	-0.143*	-0.157**
BW	-0.024	-0.051	-0.014	0.267***	-0.073	-0.097	-0.118*
BMI	0.048	0.019	0.048	0.135*	0.027	0.011	0.004
AGE	0.181**	0.092	0.200***	0.269***	-0.012	0.076	0.041

Legend: BH – body height; BW – body weight; BMI – body mass index; P – total points; G – goals scored; A – assists; PIM – penalty minutes; G/GP – goals per games played; A/GP – assists per games played; P/GP – points per games played; * – statistical significance $p < 0.05$; ** – statistical significance $p < 0.01$; *** – statistical significance $p < 0.001$

In ice hockey forwards, a similar trend of significant associations was observed between body height, body weight, BMI and a higher amount of penalty minutes. Negative behaviour represented by penalty minutes in ice hockey forwards showed the highest values relative to increasing age. Increasing age of ice hockey forwards also significantly corresponded with player success represented by the overall number of individual points. Similarly, number of goals scored was positively associated with increasing age, the same applies to number of assists (Table 3).

Table 3. Spearman's correlation of body height, body weight and BMI with indicators of player success in current NHL forwards

Forwards	P	G	A	PIM	G/GP	A/GP	P/GP
BH	-0.006	-0.006	-0.008	0.145***	-0.051	-0.048	-0.066
BW	-0.038	-0.027	-0.039	0.226***	-0.084*	-0.099*	-0.110**
BMI	-0.037	-0.024	-0.042	0.149***	-0.049	-0.079	-0.071
AGE	0.192***	0.169***	0.206***	0.325***	0.091*	0.109**	0.091*

Legend: BH – body height; BW – body weight; BMI – body mass index; P – total points; G – goals scored; A – assists; PIM – penalty minutes; G/GP – goals per games played; A/GP – assists per games played; P/GP – points per games played; * – statistical significance $p < 0.05$; ** – statistical significance $p < 0.01$; *** – statistical significance $p < 0.001$

Discussion

The importance of optimum development of somatic parameters in ice hockey players is indisputable. Especially with regard to the ongoing dynamic development of the sports discipline, increasing level of the top world leagues, or specific requirements based on various player roles.

Since 1920s, the average body height of NHL players has increased by more than 10 cm and body weight by more than 17 kg (Montgomery, 2006). In Czech players for example, the average body height has also increased by more than 10 cm since late 1928s, and body weight by more than 21 kg. It should be noted however that North American players have always been taller and heavier. This is now beginning to equalize as a result of selecting players who meet the high demands placed on the development of somatic parameters. This is particularly noticeable in drafting young players to the NHL. Also internationally, there is a clear trend of increasing body height and body weight. For example, the Czech ice hockey team has players with the required values of key somatic parameters at important sports events. This was most apparent in the Czech national team for the Olympic Games 2014 in Sochi (Russia), where the average value of body height was almost 187 cm and

body weight over 93 kg (CIHA, 2014). Of course there are some differences regarding gaming positions. A current trend is increasing body height in ice hockey goalkeepers. Also in the senior category at an international level and particularly in the NHL there are now more ice hockey goalkeepers with body height ranging from 190 to 200 cm (Kutáč & Sigmund, 2015). Average body height of current NHL goalkeepers is 188.3 cm (Sigmund, Kohn & Sigmundová, 2016). Increasing demands for body height of ice hockey goalkeepers are also confirmed by individual values of goalkeepers from the first four teams at the last World Championship 2016 in Moscow and St. Petersburg (Russia). Body height of the US goalkeeper (placed fourth) and the Russian goalkeeper (placed third) was > 188 cm. Body height of the Canadian goalkeeper (Ice Hockey World Champion 2016) was 191 cm and body height of the Finnish goalkeeper (placed second) was even 196 cm (International Ice Hockey Federation, 2016).

In general, it is apparent that the development of somatic parameters in ice hockey players has a positive trend and is associated with the dynamic development of the sports discipline. Internationally, differences were observed with respect to ranking (Sigmund, Riegerová, Sigmundová, & Dostálová, 2014), differences were also observed between players from various leagues (Kutáč & Sigmund, 2015; Sigmund, Sigmundová, & Kvintová, 2015) and with respect to gaming positions (Sigmund, Kohn, & Sigmundová, 2016; Sigmund, Sigmundová, & Kvintová, 2015).

A positive trend of the development of somatic parameters in ice hockey players is apparent. The question is: “How do the values of basic somatic characteristics affect the achievement of individual in-game player performance and player success?”

The results of our study suggest some associations between the monitored physical parameters and objectively measured values of individual player performance. In the case of NHL goalkeepers, no significant associations were observed between the values of body height, body weight and BMI, and objective indicators of goalkeeper player success. The study suggested a significantly negative association in defenders between body height and player productivity represented by individual points per game. In the case of forwards the study suggested as association between body weight and the average number of points per game. Other associations of the monitored somatic indicators are rather related to negative player behaviour, which is represented by the number of penalty minutes. In addition to the monitored physical parameters, a major determinant of player performance seems to be the age factor. Increasing player age corresponds with the indicators of player success in many monitored parameters in all gaming positions. The age range of current NHL players is between 18 and 44 years; the average age is 26.5 ± 4.49 years. This corresponds with the fact that the age range of top ice hockey performance is currently 23 to 33 years with most values between 25 and 29 years (Vobr, 2011). The optimum top performance age in the career of an elite ice hockey player appears to be 27 to 28 years (Sigmund & Dostálová, 2011). In the context of these facts it appears that if a drafted player, mostly between 18 and 20 years of age, succeeds in an NHL team and secures a stable position in the team, he has another seven to ten years of growth to achieve maximum performance and maximum use of own potential.

Based on the findings it is impossible to positively confirm a direct relationship between the monitored somatic parameters such as body height, body weight and BMI, and objective indicators of individual player success of goalkeepers, defenders and forwards. Objective player success will be potentiated by other variables, especially the development of specific physiologically conditioned abilities and individual player skills (Tanner & Gore, 2013). At present, the functional development of elite ice hockey players focuses on strength development as the fundamental aspect, and anaerobic performance development (Burr, Jamnik, Baker, Macpherson, Gledhill, & McGuire, 2008; Hoff et al., 2005; MacLean, 2008). The development of strength abilities focuses primarily on the overall strength of the trunk, extensors of the hip and knee joint, hip adductors and abductors, musculus triceps brachii and musculus deltoideus (Brocherie et al., 2005; Manners, 2004; Queinny et al., 2008). The development of elite ice hockey players further focuses on the development of aerobic abilities, speed abilities and agility (Behm, Wahl, Button, Power, & Anderson, 2005; MacLean, 2008; Vescovi et al., 2006).

A current effort is to effectively transfer the above mentioned abilities and skills to game and individual player performance. We assume that the area of further development of ice hockey players includes significant factors affecting individual player performance measurable by objective player success.

Conclusion

The present paper analysed the physical characteristics and age of current professional NHL players in relation to gaming positions and player success. The findings did not positively confirm significant associations between the parameters of body height, body weight and BMI on the one hand, and the monitored indicators of player success of goalkeepers, defenders and forwards on the other hand. On the contrary, the study indicated significant associations between the basic physical parameters and negative player behaviour represented by an increased number of penalty minutes, especially for defenders and forwards. Apart from the basic physical parameters, a major determinant of player performance seems to be the age factor. It was revealed that increasing player age corresponds with player success in many monitored parameters in all gaming positions. The findings

help clarify the determinants affecting the overall performance in ice hockey players with regard to their gaming positions in the NHL.

Conflicts of interest - None

References:

- Barzilay D. (2002). Evaluation structure for determining performance value of developing hockey players. *Acta Universitatis Carolinae: Kinanthropologica*, 38, 5–27.
- 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.
- Blanchard, K. (1995). *The Anthropology of Sport: An Introduction (A Revised Edition)*. Westport: Bergin & Garvey, Greenwood Publishing Group, Inc.
- Bolin, A., & Granskog, J. (Eds). (2003). *Athletic Intruders: Ethnographic Research on Women Culture and Exercise*. Albany, NY: SUNY Press.
- Brocherie, F., Babault, N., Cometti, G., Maffiuletti, N., & Chatard, J. C. (2005). Electrostimulation training effects on the physical performance of ice hockey players. *Medicine & Science in Sports & Exercise*, 37(3), 455–460.
- 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, 1535–1543.
- CIHA (2014). <http://www.cslh.cz/reprezentace/1-a-tym.html>
- Geithner, C. A., Lee, A. M., & Bracko, M. R. (2006). Physical and performance differences among forwards, defense, and goalies in elite women's ice hockey. *Journal of Strength and Conditioning Research*, 20, 500–505.
- Gledhill, N., & Jamnik, V. (2007). *Detailed Assessment Protocols For NHL Entry Draft Players*. Toronto: York University.
- Hoff, J., Kemi, O. J., & Helgerud, J. (2005). Strength and endurance differences between elite and junior elite ice hockey players. The importance of allometric scaling. *International Journal of Sports Medicine*, 26(7), 537–541.
- IIHF Ice Hockey World Championship 2016. <http://www.iihfworlids2016.com/>
- Kutáč P., & Sigmund, M. (2015). A comparison of somatic variables of elite ice hockey players from the Czech ELH and Russian KHL. *Journal of Human Kinetics*, 45, 129–137.
- Malina, R. M., Bouchard, C., & Bar-Or, B. (2004). Growth, maturation, and physical activity. Champaign, IL: Human Kinetics.
- Manners, T. W. (2004). Sport-specific training for ice hockey. *Strength & Conditioning Journal*, 26(2), 16–21.
- McArdle, W. D., Katch, F. I., & Katch, V. L. (2010). *Exercise Physiology: Nutrition, Energy, and Human Performance*. Baltimore (MD): Lippincott Williams & Wilkins.
- MacLean, E. (2008). Full Year Periodized Sport Specific Conditioning Program for the Canadian Junior Hockey Player. *A theoretical review of the physiological demands of ice hockey*, 1–16.
- Montgomery, D. L. (2006). Physiological profile of professional hockey players a longitudinal study. *Applied Physiology, Nutrition and Metabolism*, 31, 181–185.
- NBA Combine Fitness Testing (2016). <http://www.topendsports.com/sport/basketball/testing-nba-draft.htm>
- NFL Combine: Step-by-step guide to player drills and scouts' takes (2016). <http://www.cbssports.com/nfl/draft/nfl-draft-scout/25492933/nfl-combine-do-you-know-the-drill>
- NHL Nationality Breakdown from 1917-18 to 2014-15; http://www.quanthockey.com/TS/TS_PlayerNationalities.php
- NHL Scouting combine fitness testing summary (2015). http://avalanche.nhl.com/v2/ext/draft/2015/Combine/2015_Combine_Fitness_Test_Event_Summary_FIN_AL.pdf
- Norton, K., & Olds, T. (2001). Morphological Evolution of Athletes Over the 20th Century. *Sports Medicine*, 31(11), 763–783.
- Palmer, M. S., & Spriet, L. L. (2008). Sedat rate, salt loss, and fluid intake during an intense on-ice practice in elite Canadian male junior hockey players. *Applied Physiology, Nutrition, and Metabolism*, 33(2), 263–271.
- Perič, T., & Dovalil, J. (2010). *Sportovní trénink*. Praha: Grada.
- QuantHockey, 2015. http://www.quanthockey.com/TS/TS_PlayerNationalities.php
- Quinney, H. A., Dewart, R., Game, A., Snyder, G., Warburton, D., & Gordon, B. (2008). A 26 year physiological description of a National Hockey League team. *Applied Physiology, Nutrition and Metabolism*, 33, 753–760.

- Roczniok, R., Maszczyk, A., Stanula, A., Czuba, M., Pietraszewski, P., Kantika, J., & Starzyński, M. (2013). Physiological and physical profiles and on-ice performance approach to predict talent in male youth ice hockey players during draft to hockey team. *Isokinetics & Exercise Science*, 21, 121–127.
- Sigmund, M., & Dostálová, I. (2011). The basic morphological characteristics, body composition and segmental analysis in elite-level ice hockey players of the professional russian hockey league. *Česká antropologie*, 61(2), 25–31.
- Sigmund, M., Riegerová, J., & Dostálová, I. (2012). Development of the basic morphological characteristics in the elite-level senior ice hockey players in the Czech Republic in the context of years 1928–2010. *Česká antropologie*, 62(2), 29–35.
- Sigmund, M., Riegerová, J., Sigmundová, D., & Dostálová, I. (2014). Analýza základních morfologických charakteristik současných světových seniorských hráčů ledního hokeje ve vztahu k výkonnostní úrovni podle rankingu Mezinárodní hokejové federace. *Česká antropologie*, 64(2), 34–39.
- Sigmund, M., Sigmundová, D., & Kvintová, J. (2015). Basic physical profile of current Czech elite male ice hockey players - references values. *Life Science Journal*, 12(2), 9–13.
- Sigmund, M., Kohn, S., & Sigmundová, D. (2016). Assessment of basic physical parameters of current Canadian-American National Hockey League (NHL) ice hockey players. *Acta Gymnica*, 46(1), 30–36. doi: 10.5507/ag.2015.027
- Skowronek, T., Socha, T., Roczniok, R., & Socha, S. (2013). The predictive value of various anaerobic capacity indices in relation to specific on-ice performance tests in ice hockey players. *Life Science Journal*, 10(4), 2228–2832.
- Szmatlan-Gabryś, U., Stanula, A., Gabryś, T., & Ozimek, M. (2014). Segmental body composition in male and female ice-hockey players. *Life Science Journal*, 11(5), 389–395.
- Tanner, R., & Gore, Ch. (2013). *Physiological Tests for Elite Athletes* (2nd ed.). Champaign, IL: Human Kinetics.
- Tarter, B. C., Kirisci, L., Tarter, R. E., Weatherbee, S., Jamnik, V., McGuire, E. J., & Gledhill, N. (2009). Use of Aggregate Fitness Indicators to Predict Transition into the National Hockey League. *Journal of Strength Conditioning Research*, 23(6), 1828–1832.
- Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2011). *Research methods in physical activity* (6th ed.). Champaign, IL: Human Kinetics.
- Vescovi, J. D., Murray, T. M., & Van Heest, J. L. (2006). Position performance profiling of elite ice hockey players. *International Journal of Sports Physiology and Performance*, 1, 84–94.
- Vobr, R. (2011). *Možnosti analýzy věku vrcholné výkonnosti na příkladu atletiky, plavání, běžeckého lyžování, ledního hokeje a fotbalu*. Habilitační práce. Brno: FSpS, Masarykova univerzita