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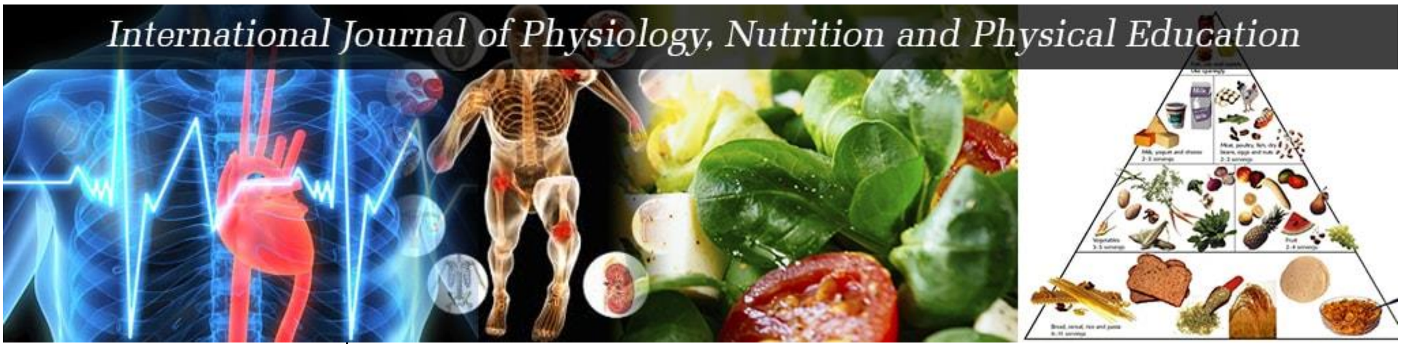

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Limiting factors of skating performance in ice hockey

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Abstract
This work refers to determining factors of skating performance in ice hockey. We suppose that the performance in the ice hockey tests is limited by some factors as the explosive power of lower limbs and dynamic balance. The skating tests with various difficulty and tests of maximal muscle strength of lower limbs, vertical jump with counter-movement and without counter-movement, standing long jump, single leg lateral jump from left and right foot and the test of dynamic balance on the right and left foot were put to the relationship analysis.
In determining the performance limiting factors, we are coming up from the multiple correlations and regression analysis. For the reduction of indicators, the stepwise analysis was used.
When speaking about the indicators of explosive power of lower limbs, the most influential parts of ice skating performance are the tests of muscle strength of lower limbs, lateral jumps and the vertical jump with counter-movement. Tests of dynamic balance have not been established as the limiting factors.
The mentioned factors were showed as significant in the more challenging test as skating to the 5-7-5 meters ($p<0,05$) and in the Weave agility test ($p<0,01$). The complex of these factors explains significantly ($p<0,05$) with large effect ($f^2>0,35$) the reliability of models on 55,0 % and 81,4 %. Selected tests, however, have shown as the statistically nonsignificant in the acceleration skating speed to the 10 meters and in Transition test. From the all ice skating tests, the highest consistency with the strength-power factors has the Weave test, which was proven statistically, practically and also by intercorrelation. An assumption about the impact of the explosiveness of lower limbs has been confirmed only in maximal muscle performance and in the lateral jump from the left and right foot.

Keywords: Ice hockey, ice skating, performance, strength, balance

Introduction

Ice hockey is physically demanding collective sport which is characterized by high-intensity ice skating by short phases on an anaerobic level. Depending on the hockey level, players substitution in the match mostly lasts 30 to 60 seconds (Montgomery, 1988) [19]. In this phase, there are rapid changes in movement and direction, so the ice hockey player must have mastered basic skating skills (Mascaro, Seaver, & Swanson, 1992) [18]. Ice skating requires the ability to repeatedly develop high performance in connection with the acceleration of the player ´s body weight (Price, 2003) [20]. In spite of the important skills of stickhandling, it is necessary to place great emphasis on leg work. Therefore it is necessary to know the limiting factors of sports performance and to assign them proper diagnostic tests.

In the structure of playing performance with dependence on the coordination, there is a high contribution of strength and speed abilities (Kostka, Bukac & Safarik, 1986) [16]. For example, if the player is able to skate faster than his opponent, he has a higher chance to get a free puck as first with the use of his spatial ability. Strength abilities in ice hockey can be diagnosed through the various jumps, for example by repeated jumps, with or without load with the help of special diagnostic tools.

For detection of the level of special coordination abilities, it is appropriate to use various obstacle courses with the direction changing which are also known as the agility tests. Based on the results we can change the training process and make it more effective. Knowledge of the limiting factors of complex hockey skills from the viewpoint of speed and special coordination can be helpful to increase the player´s performance in the match. According to these facts, our aim in this research will be to determine the factor structure of motor skills of an ice hockey player (Farlinger, Kruisselbrink & Fowles, 2007) [10].

Aim

The aim of this work is to contribute to a clarification of determining factors of the performance in the ice hockey skating tests. According to the empirical literature, we consider that the performance in skating tests is limited by factors such as the explosive power of lower limbs and dynamic balance.

In the level of the explosive power of lower limbs, we considered that the performance is mainly depended on the maximal muscle performance, on the vertical jump with countermovement and on the distance from the lateral jump from left and right foot.

The hypothesis was verified by determining the level of individual factors in relation to the skating performance in tests of different difficulty.

Methodics

We monitored 14 first-league ice hockey players in the Czech Republic in the average age of M = 17,36 SD = 0,50. The average body height of monitored players was M = 180,43 SD = 7,13 cm and body weight was M = 75,43 SD = 10,92 kg.

Level of the physical development, skating tests, explosion strength of lower limbs (maximal muscle performance, vertical jump with and without countermovement, standing long jump, single leg lateral jump from left and right foot) and dynamic balance on the right and left foot (Y-Balance test by Shaffer 2013, Hoch *et al*. 2017) [23, 13] are characterized by the mean (M), standard deviation (SD), minimum (Min), maximum (Max) and by percentiles (25 %, 50 %, 75 %). Normality of the distribution of the variables was assessed by Kolmogorov Smirnoff and Shapiro-Wilk test (table 1).

The ice hockey skating tests were realized according to the methods of the Airdrie Minor Hockey Association (AMHA, 2018) [1]. Tests as the skating acceleration to the 10m, change of direction speed 5-7-5 m, change of direction speed Weave test and the Transition test were assessed in seconds. All of these tests were performed without puck carrying.

For the measurement of the vertical jump with and without a countermovement the jump ergometer, Fitro Jumper (cm), have been used. For the measurement of maximal muscle performance (W) in squat jump with a barbell with a 50 % and 70 % weight of player ´s body weight, the Fitro Dyne Premium (Fitronic, 2017) [12], have been used.

When determining the limiting factors of an ice hockey skating tests, we come from the evaluation of the dependency between all motoric variables. For reduction of the indicators, we used the step regression analysis. In this technique, we used the method Backward, which is characterized by gradual earmarking variables from the total set in the regression function. These are tested in back-coupling whether they statistically impact the quality of the regression model.

Relation (Pearson r) and a ratio (βeta*r) of individual factors, has been estimated by correlation and regression analysis technique. Besides the multiple correlation coefficient (R), the determinant of multiple correlations (R^2), a standard error of regression (SEE), coefficients of partial regression (b), factor significance (t) and significance of model (F), have been calculated. The effect size is measured by Cohen´s f^2 (Cohen, 1998). Statistics significance is measured in the significance level p<0,05, p<0,01 and effect size in 0,02 = small, 0,15 = medium, 0,35 = large effect. Empirical data were evaluated in MS Excel and SPSS programs.

Results

All monitored ice hockey players are on the optimum age for achieving high sports performance. Average values of physical development indicators indicate good preconditions for hockey specialization. However, we did not use the indicator of physical development when we detected the determinant factors. To the relationship analysis, we put only skating tests, a test of the explosive power of lower limbs and dynamic balance tests.

Table 1: Descriptive statistics of somatic indicators, ice skating tests, a test of the explosive power of lower limbs and test of dynamic balance in the ice hockey players

					Percentiles			Kolmogorov Smirnov test		Shapiro-Wilk test	
	M	SD	Min	Max	25th	50th	75th	Stat.	Sig.	Stat.	Sig.
Age	17,36	0,50	17,00	18,00	17,00	17,00	18,00	0,41	0,00	0,62	0,00
Body height [cm]	180,43	7,13	169,00	190,00	174,25	181,00	187,00	0,14	0,20	0,92	0,22
Body weight [kg]	75,43	10,92	62,20	96,90	69,15	72,20	76,90	0,23	0,04	0,85	0,02
10 m test [s]	1,89	0,05	1,83	1,98	1,85	1,89	1,93	0,14	0,20	0,95	0,53
5-7-5m test [s]	4,46	0,18	4,26	4,79	4,29	4,45	4,60	0,17	0,20	0,91	0,14
Weave test [s]	11,72	0,49	11,14	12,97	11,39	11,67	11,94	0,18	0,20	0,89	0,09
Transition test [s]	14,82	0,62	14,20	16,40	14,39	14,60	14,99	0,22	0,07	0,82	0,01
Squat Jump 50% [W]	458,74	81,96	310,40	584,40	407,70	456,55	507,65	0,13	0,20	0,97	0,84
Squat Jump 70% [W]	573,24	81,35	421,30	732,70	524,45	553,95	619,40	0,14	0,20	0,98	0,97
Vertical jump with counter-movement [cm]	34,73	4,87	28,50	46,80	31,10	33,75	36,80	0,21	0,09	0,90	0,10
Vertical jump without counter-movement [cm]	28,39	3,79	21,60	38,90	26,63	28,15	29,58	0,24	0,09	0,86	0,09
Standing long jump test [cm]	233,36	14,28	209,00	260,00	222,50	236,50	242,25	0,13	0,20	0,98	0,95
Single leg lateral jump - Left leg [cm]	201,86	11,78	172,00	219,00	198,25	203,00	208,75	0,16	0,20	0,93	0,31
Single leg lateral jump - Right leg [cm]	202,29	12,86	170,00	220,00	194,75	206,00	207,75	0,19	0,20	0,91	0,16
Y-balance test Left leg [cm]	102,14	5,87	92,56	111,61	97,42	100,73	106,83	0,14	0,20	0,95	0,56
Y-balance test Right leg [cm]	103,14	7,85	92,88	114,61	97,17	101,85	110,78	0,18	0,20	0,90	0,11

The multiple correlations and regression analysis allowed us to optimally reduce the observed factors to the number that would most likely explain the ice hockey performance (table 2-5). From the explosive power of lower limbs factors, confirmed the affinity only the tests of muscle performance in squat jump with a barbell with a 50 % and 70 % weight of player ´s body weight, single leg lateral jump, and vertical jump with countermovement. Tests of dynamic balance, Y balance tests, did not establish themselves between the limiting factors.

Table 2: Correlation and regression analysis of selected factors influencing the acceleration speed in the 10 m skating test

10 m test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 50 %	-0,374	0,000	0,083	-0,221	0,448	1,350	0,207
Standing long jump test	-0,289	-0,001	0,150	-0,521	0,056	0,919	0,380
Single leg lateral jump - Right leg	-0,401	-0,001	0,170	-0,424	0,131	1,178	0,266
R^2	0,403		SEE	0,041		F	2,247
R	0,635		bo	2,504		sig	0,145
f^2	0,674						

Table 3: Correlation and regression analysis of selected factors influencing 5-7-5 m skating test

5-7-5 m test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 50 %	-0,885	-0,002	0,042	-0,048	0,892	2,227	0,050
Squat Jump 70 %	0,720	0,002	0,104	0,144	0,607	1,878	0,090
Single leg lateral jump - Left leg	-0,710	-0,011	0,404	-0,568	0,033	3,125	0,011
R^2	0,550		SEE	0,139		F	4,068
R	0,742		bo	6,649		sig	0,040
f^2	1,224						

Combination of factors is differentiated to the skating tests and their difficulty. Reduced factors explain significantly and with the large effect the reliability of models in skating to 5-7-5m (R^2 = 0,55 %; f^2 = 1,224; F = 4,068; p<0,05), in the Weave test (R^2 = 0,814 %; f^2 = 4,369; F = 9,799; p<0,01) and in Transition test (R^2 = 0,599 %; f^2 = 1,492; F = 4,97; p<0,05). The set of independent factors correlated to the skating acceleration speed to 10 meters appear to be statistically insignificant in overall (F = 2,247; p = 0,145) as well as intercorelated (p>0,05).

From the speed-strength factors of lower limbs, with the increasing difficulty of skating tests, the muscle performance of lower limbs is most often promoted. Also the same can be found in all variants of single leg lateral jumps, which with his implementation is closest to the technical execution of ice skating. Vertical jump with countermovement has a significant part of the explanation of performance in the more difficult tests with a change of direction in speed (Weave test and Transition test).

From all skating tests have the highest consistency with speed-strength factors the Weave test, which was proven statistically, practically and by intercorrelation (table 4). For prediction of the performance in the Weave skating test we can build a regression equation with 81,4 % of reliability and with 0,255 s. error.

$$y = 8{,}357 + 1{,}450{*}x^1 - 1{,}529{*}x^2 - 0{,}855{*}x^3 + 1{,}409{*}x^4$$

Explanatory notes:
y - predicted skating performance with a change of direction in the Weave test [s]
x^1 - Squat jump performance with a barbell with a 50% and 70% weight of player ´s body weight [w]
x^2 - performance in the vertical jump with countermovement in Fitro Jump test [cm]
x^3 - performance in single leg lateral jump with left foot [cm]
x^4 - performance in single leg lateral jump with a right foot [cm]

Table 4: Correlation and regression analysis of selected factors influencing Weave agility test

Weave test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 70 %	1,450	0,009	0,555	0,383	0,177	4,569	0,001
Vertical jump with counter-movement	-1,529	-0,154	0,555	-0,363	0,202	4,403	0,002
Single leg lateral jump - Left leg	-0,855	-0,036	0,497	-0,581	0,029	3,323	0,009
Single leg lateral jump - Right leg	1,409	0,054	-0,793	-0,563	0,036	3,244	0,010
R^2	0,814		SEE	0,255		F	9,799
R	0,902		bo	8,357		sig	0,002
f^2	4,369						

Table 5: Correlation and regression analysis of selected factors influencing Transition test

Transition test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 70 %	0,523	0,004	0,218	0,417	0,138	1,977	0,076
Vertical jump with counter-movement	-0,404	-0,052	0,111	-0,275	0,341	1,484	0,169
Single leg lateral jump - Left leg	-0,408	-0,022	0,270	-0,662	0,010	1,683	0,123
R^2	0,599		SEE	0,451		F	4,970
R	0,774		bo	18,677		sig	0,023
f^2	1,492						

Discussion

In our study, we focused on factors limiting the ice skating performance. We supposed that the performance in the ice hockey tests is limited by some factors as the explosive power of lower limbs and dynamic balance. Monitored factors were reduced by the multiple correlations and regression analysis to such a number, which is most likely to explain the skating performance. From the explosive power of lower limbs factors, confirmed the affinity only the tests of muscle performance in squat jump with a barbell with a 50 % and 70 % weight of player ´s body weight, single leg lateral jump, and vertical jump with countermovement. Tests of dynamic balance, Y balance test, did not establish themselves between the limiting factors, which was proven by Krause *et al*. (2012) [17] but it does not match with the results from the study of Behm *et al*. (2005) [2], who found statistically significant relation between the skating sprint to the 36 meters test and with the results in Y-Balance test. This relation was on the level $p<0,05$.

The set of independent factors correlated to the skating acceleration speed to 10 meters appears as statistically non-significant, overall (F = 2,247; p = 0,145) also by intercorrelation ($p>0,05$), which is in contradiction with Sobota (2015) [25], Mascaro *et al*. (1992) [18] and Runner *et al*. (2015) [22]. These authors found significant relations between the skating sprint and the explosive power of lover limbs level in the tests of vertical jump with countermovement and standing jump test. Another significant predictor of speed in skating found in our study was the result measured in single leg lateral jump from the left and right foot. Statistically significant relation was measured between the performances in single leg lateral jump from left foot and in 5-7-5 skating test ($p<0,05$), then between the Weave test, single leg lateral jump from left foot ($p<0,01$) and single leg lateral jump from right foot ($p<0,01$). The single leg lateral jump from left foot was also a significant predictor of the level of skating speed in the Transition agility test ($p<0,05$). Our results were confirmed in studies by Bracke-Geither (2009) [5] and Skinner (2008) [24], who find out that the width of skating take-off has a significant impact on the skating speed. Since Farlinger, Fowles (2008) [11], who demonstrated a correlation between the explosive power in the lateral plane with skating speed, the agreement with these authors can be confirmed. Also, Reyment *et al*. (2006) [21] mentioned the dominance of a single leg at skating, which was confirmed also in our study.

In our study, we also identify the important relationship between the height of the vertical jump with countermovement and the level of skating speed measured in 5-7-5 test ($p<0,01$), then in Weave test ($p<0,01$) and also in Transition Agility test ($p<0,05$). The same results were measured in studies of Runner *et al*. (2015) [22], Mascaro *et al*. (1992) [18], Sobota (2015) [25]. On the other side Bracko & George (2001) [6], Blatherwick, (2005) [4], Bracko & George (2001) [6] a Diakoumis, and Bracko (1998) [9] measured the opposite.

The last important predictor affecting the skating speed found in our study was the muscle performance measured in Squat Jump with a barbell of 50% and 70% body weight load. We find that the measured performance in Squat Jump test with 70% of body weight load most affected the level of skating speed in Weave agility test ($p<0,01$). Similar results were measured by Burr *et al*. (2007) [7] and Ferlinger *et al*. (2007) [10]. These results did not match with the study results of Behm *et al*. (2005) [2], who demonstrated the lower correlation between the muscle performance and skating speed ($p<0,05$).

Conclusion

This work helped to clarify the factors determining performance in ice hockey skating tests. Affinity to the performance in skating tests from the explosive power of lower limbs and dynamic balance factors were proven in the test of muscle performance of lower limbs, single leg lateral jump and vertical jump with countermovement. Dynamic balance tests did not fit into the limiting factors.

These factors have shown significant interactions with more difficulty skating tests as 5-7-5m. and in Weave agility test. Selected factors of muscle performance, standing long jump, vertical jump, and lateral jump did not show their significance in acceleration skating speed in 10 m test and in Transition test.

From the all skating tests have the highest consistency with speed-strength factors the Weave test, which was proven statistically, practically and by the intercorrelation.

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