DEPENDENCE OF THE SKATING AND RUNNING PERFORMANCE FROM THE EXPLOSIVE STRENGTH OF LOWER LIMBS AND DYNAMIC BALANCE OF ICE HOCKEY PLAYERS

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Abstract
This work refers to the dependence of the skating and running performance from the explosive strength of lower limbs and dynamic balance of an ice hockey player in the youth category. We suppose that the performance in the skating and running tests is limited by some factors as the explosive strength of lower limbs and dynamic balance and they create differentiated hierarchy according to the test difficulty. The ice skating tests and running tests were put to the relationship analysis as the dependent variables. Independent variables were formed by tests of maximal muscle strength of lower limbs, vertical jump with and without countermovement, standing long jump, single leg lateral jump from left and right foot and the test of dynamic balance on the right and left foot. In determining the limiting factors of performance in skating and running tests, we are coming out of the multiple correlation and regressions analysis. For the reduction of indicators, the stepwise analysis was used. From explosive strength of lower limbs indicators has a decisive contribution to the explanation of skating and running performance the vertical jump with countermovement, standing long jump and test of muscle performance of lower limbs. Single leg jump tests had the smallest part in these indicators. Dynamic balance tests have an impact only in 5-10-5 meters running test. From all skating tests have the highest consistency with tests of explosive strength of lower limbs the 5-10-5 test, which was proven statistically (F = 10,490; p<0,01), by intercorrelation (p<0,05) and practically (f2 = 1,592). From all running tests, the highest consistency with tests of explosive strength has the run to 10 meters test, which was proven statistically (F = 9,181; p<0,01), by intercorrelation (p<0,05) and practically (f2 = 0,706). In both cases are the partial proportions in individual parameters in positive relation to the skating and running performance. The assumption about the impact of the explosive strength of lower limbs and dynamic balance to the performance in the skating and running tests has been confirmed in the vertical jump, maximal muscle performance and in the standing long jump. The differentiated hierarchy of factors according to the test difficulty and their performance in the ice or in dry land has been proven.

Key words: *ice hockey, skating, running, performance, explosive strength, dynamic balance.*

Introduction

Ice hockey is physically demanding, contact sport. As in other collective sports, it is a meeting of players who perform short-term, high-intensity impulses at a maximum performance during a certain time (Bishop, Lawrence, Spencer, 2003). This whole process runs with speed acceleration and with direction changing movements of players (Buchheit, Lefebvre, Laursen, Ahmaidi, 2011). In order for hockey players to be able to play at the top level, it is important to increase their anaerobic threshold, aerobic endurance, and muscle strength (Wilson, Snydmiller, Game, Quinney, Bell, 2010). Due to these demanding requirements, the physical tests of players are regularly realized already before the competitive season, and they can continue during the season (Power, Faught, Przysucha, McPherson, Montelpare, 2012). Results of these tests can significantly influence the decision of coach about the timing of individual play time for the season and also they can be a good predictor of game success (Durocher, Leetun, Carter, 2008).Based on these results the coach will decide about the playtime of a hockey player on the ice in a certain match, which can strongly influence his carrier (Burr, Jamnik, Baker, Macpherson, Gledhill, McGuire, 2008). An important role in the player´s performance plays his skating skills (Price, 2003). The most characteristic feature based on the claims of elite hockey players is the maximal skating speed (Marino, 1983). Endurance, muscle strength and also the coordination is important too (Bracko, Fellingham, 1997). The ice skating training can increase these factors, which are limiting for the skating and running performance (Greer, Serfass, Picconatto, Blatherwick, 1992). It means that some relation exists between the skating performance on ice and the special exercises used to achieve this performance. In regard to this fact, it is necessary to apply the development of the dynamic balance and explosive strength of lower limbs as the devices of sports training.

Aim

The aim of this work is to contribute to the hierarchy of factors which determine the performance in the ice hockey skating tests and running tests. According to the empirical literature, we consider that the performance in skating tests is limited by factors such as the explosive strength of lower limbs and dynamic balance. We consider that these factors will create a differentiated hierarchy according to the test difficulty.

Methodics

The monitored group consisted of 29 hockey players from HK DuklaTrenčín in the average age of M = 16,79 SD = 0,71 who actively play in a youth league in the Slovak Republic. The average body height of monitored players is M = 180,45 SD = 5,05 cm and and body weight M = 73,77 SD = 7,94 kg.

The level of physical development, skating tests, explosion strength of lower limbs (maximal muscle performance, vertical jump with and without a countermovement, standing long jump, single leg lateral jump from the left and right foot) and dynamic balance on the right and left foot are characterized by the mean (M), standard deviation (SD), minimum (Min), maximum (Max) and by percentiles in table 1. The ice hockey skating tests were realized according to the methods of the Airdrie Minor Hockey Association (AMHA, 2018). Tests as the skating and running acceleration speed to the 10 meters (both by the same realization), skating and running changes of direction in speed Weave test is assessed in seconds. All of these tests were without puck carrying. For the evaluation of dynamic balance on the right and left foot, we used the methods of Y-Balance test (Hoch et al. 2017, Shaffer 2013). 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 50% of the player ´s body weight load, the Fitro Dyne Premium (Fitronic, 2017) was used. When determining the limiting factors of the ice hockey skating tests, we came from the evaluation of the dependency between all motoric variables. For reduction of the indicators, we used the step regression analysis with Backward method.

This method is characterized by the gradual incorporating of variables from the total set in the regression function. These variables are tested in back-coupling whether they statistically impact the quality of the regression model. Relation (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 (R2), 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 f2 (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 hockey players already have enough years of training to reach the maximum sports performance which means that players have optimal age to achieve the top sports performance. A decisive precondition for the hockey specialization are the average values of physical development indicators (Kokinda & Turek, 2015). In this study, we did not use the indicators of physical development to detect determining factors. To the relation analysis, we inserted only the skating tests, tests of explosion strength of lower limbs and the dynamic balance tests. The multiple correlations and regression analysis allowed us to optimally reduce the observed factors to the number that would most likely explain the skating performance (table 2-4) and running performance (table 5-6).

From the factors of the explosion strength of lower limbs, all tests confirmed the affinity to the performance, mostly the squat jump test with a barbell with 50% of the player ´s body weight load. Tests of dynamic balance - Y-balance tests did not establish themselves between the limiting factors. In the running tests confirmed the affinity test of muscle performance in the exercise squat jump with a barbell with 50% of the player ´s body weight load, vertical jump with countermovement, standing long jump and Y-balance tests of dynamic balance. Single leg lateral jumps did not establish themselves between the limiting factors.

The set of factors are differentiated according to the skating tests, running tests and their performance difficulty. The reduced factors explain significantly and with the large effect the reliability of models in skating in tests to 10meteres (R2 = 0,3140; f2 = 0,4581; F = 3,8179; p<0,05), in skating test to the 5-10-5 meters (R2 = 0,6143; f2 = 1,592; F = 13,270; p<0,01) and in Weave test (R2 = 0,4466; f2 = 0,8069; F = 10,490; p<0,01). Also in the dry land tests in the acceleration run to 10 meters (R2 = 0,4139; f2 = 0,7062; F = 9,181; p<0,01) and in 5-10-5 m running test (R2 = 0,635; f2 = 1,737; F = 14,475; p<0,01). From the speed-strength factors of lower limbs with the increasing difficulty of skating tests, increasing muscle performance of lower limbs and vertical jump with countermovement most commonly occurs. The significant part in the explanation of the performance in skating tests where direction changes were needed (5-10-5 m test and Weave test) has the vertical jump without countermovement and standing long jump. From the speed -strength factors of lower limbs in the 10 meters running test, the increasing muscle performance of lower limbs and vertical jump with countermovement are established. A significant part in the explanation of performance in the running test with changes of directions (5-10-5 m test) has the performance in the dynamic balance Y-Balance test with a left foot and also in Y-Balance test with right foot.

From running tests the highest consistency with the explosive power of lower limbs tests have the run to 10 meters which was proven statistically: (F = 9,181; p<0,01), by intercorrelation (p<0,05) and practically (f2 = 0,706).

Table 1. Descriptive statistics of somatic indicators, skating and running tests, speed-strength factors and balance tests on ice hockey players.

					Percentiles		
	M	SD	Min	Max	25th	50th	75th
Age	16,79	0,71	15,41	18,00	16,35	16,76	17,21
Body height [cm]	180,45	5,05	170,00	188,00	178,00	181,00	185,00
Body weight [kg]	73,77	7,94	60,40	88,70	68,80	72,40	78,00
Ice 10 m test [s]	1,88	0,09	1,69	2,07	1,81	1,88	1,93
Ice 5-10-5m test [s]	4,69	0,22	4,21	5,08	4,59	4,70	4,82
Ice Weave test [s]	11,27	0,36	10,50	12,05	10,99	11,24	11,48
10 m test [s]	1,80	0,07	1,67	1,94	1,76	1,81	1,85
5-10-5 m test [s]	4,90	0,22	4,50	5,39	4,76	4,90	5,09
Vertical jump without counter-movement [cm]	44,84	5,07	36,40	56,40	41,70	43,40	47,70
Vertical jump with counter-movement [cm]	38,77	4,63	30,90	49,10	35,80	38,30	40,80
Standing long jump [cm]	244,22	13,93	219,30	284,40	239,80	241,40	250,60
Single leg lateral jump –Left leg [cm]	206,16	9,85	177,60	226,30	199,80	206,60	211,80
Single leg lateral jump-Right leg [cm]	207,18	10,50	181,40	225,30	200,60	208,20	215,50
Squat Jump 50% [W]	457,33	62,09	353,80	600,00	411,80	455,70	507,10
Y-balance test Left leg[cm]	105,85	5,73	96,81	119,38	102,04	105,61	109,47
Y-balance test Right leg [cm]	105,95	5,26	91,84	115,97	103,13	105,67	108,42

Table 2. Correlation and regression analysis of selected factors that influence the acceleration speed in 10m skating test.

10 m skatetest	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 50%	-0,398	-0,0006	0,146	-0,367	0,049	-2,293	0,031
Vertical jump with counter-movement	-0,554	-0,0112	0,177	-0,320	0,090	-2,493	0,020
Single leg lateral jump – Right leg	0,468	0,0042	-0,009	-0,019	0,485	2,051	0,051
R^2	0,3142		SEE	0,0819		F	3,8179
R	0,5605		bo	5,3542		sig	0,0222
f^2	0,4581						

Table 3. Correlation and regression analysis of selected factors that influence the 5-10-5 m skating test.

5-10-5 m skate test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 50%	-0,493	-0,0017	0,257	-0,521	0,004	-3,963	0,001
Vertical jump without counter-movement	-0,446	-0,0192	0,257	-0,576	0,001	-3,151	0,004
Single leg lateral jump – Left leg	-0,223	-0,0050	0,101	-0,450	0,014	-1,580	0,127
R^2	0,6143		SEE	0,1437		F	13,270
R	0,7837		bo	7,3674		sig	0,001
f^2	1,5924						

Table 4. Correlation and regression analysis of selected factors that influence the Weave test.

Weave skate test	βeta	b	βeta*r	r	sig	t	sig
Vertical jump with counter-movement	0,283	0,0222	-0,125	-0,443	0,016	1,103	0,280
Standing long jump	-0,882	-0,0229	0,572	-0,649	0,000	-3,432	0,002
R^2	0,4466		SEE	0,2798		F	10,490
R	0,6683		bo	16,0175		sig	0,001
f^2	0,8069						

Table 5. Correlation and regression analysis of selected factors that influence the acceleration speed in 10 m running test.

10 mrun test	βeta	b	βeta*r	r	sig	t	sig
Squat Jump 50%	-0,309	-0,0003	0,126	-0,408	0,027	-2,019	0,054
Vertical jump with counter-movement	-0,507	-0,0071	0,288	-0,567	0,001	-3,313	0,003
R^2	0,4139		SEE	0,0517		F	9,181
R	0,6434		bo	2,2279		sig	0,001
f^2	0,7062						

Table 6. Correlation and regression analysis of selected factors that influence the 5-10-5m running test.

5-10-5 m run test	βeta	b	βeta*r	r	sig	t	sig
Standing long jump	-0,639	-0,0103	0,430	-0,674	0,000	-5,117	0,000
Y-balance test Left leg	0,865	0,0338	-0,196	-0,226	0,237	2,933	0,007
Y-balance test Right leg	-1,025	-0,0436	0,400	-0,390	0,036	-3,480	0,002
R^2	0,6346		SEE	0,1432		F	14,475
R	0,7966		bo	12,9933		sig	0,000
f^2	1,7370						

Discussion

In our study, we took a look at the dependence of skating and running performance from the explosive strength of lower limbs and dynamic balance in ice hockey players from the youth category. We assumed that the performance in the skating and running tests is limited by factors as the explosive strength of lower limbs and dynamic balance and also that they create differentiated hierarchy according to the test difficulty.

In research, we found that from all skating tests have the highest consistency with the test of explosive strength of lower limbs has the 5-10-5m test, which was proven statistically ($F = 10{,}49$; $p<0{,}01$), by intercorrelation ($p<0{,}05$) and practically (f2 = 1,592). This fact was confirmed Blanar et al. (2019), who detected the skating speed by a similar test to 5-7-5 meters ($F = 4{,}068$; $p<0{,}05$).

One of the significant predictors of skating speed found in our study was the performance measured in single leg lateral jump test from the left and right foot. Statistically significant relation was measured between the standing long jump test and 5-10-5m skating test performance ($p<0{,}05$). It can be said that our measured results were confirmed by Bracke& Geithner (2009) and Skinner (2008), who in their study found that the width of skating take-off has significant influence to the skating speed. Also, we found the agreement with Farlinger & Fowles (2008), who have proven the correlation between the explosive strength in the sagittal plane with skating speed. Reyment et al. (2006) mentioned the dominance of a single leg at skating, which was confirmed also in our study.

Another important factor influencing the skating speed found in our study which was confirmed in the past by Runner et al. (2015), Mascaro et al. (1992), Sobota (2015) a Diakoumis & Bracko (1998), was the performance in vertical jump tests. In our study were used the vertical jump with and without a countermovement and the significant relations between the jump with countermovement were found with 10 meters of skating sprint test ($p<0{,}05$) and Weave test ($p<0{,}05$). The jump without a countermovement had a significant relation with the 5-10-5m test performance ($p<0{,}01$). These findings do not match with the findings of Blatherwick (2005) and Brack o& George (2001).

The last significant predictor influencing the skating speed found in our study was the muscle performance measured in Squat Jump test with a barbell with 50% of the player ´s body weight load. It was found that the measured performance in this test strongly influences the level of skating speed measured in 10m sprint skating test (p<0,05) mainly in 5-10-5m test (p<0,01). Our measured findings match with findings of other authors Burr et al. (2007) a Ferlinger et al. (2007) bud do not match with the findings of Behm et al. (2005)where the correlation between the muscle performance and skating speed was lower (p>0,05). The expected influence of performances in dynamic balance tests to the skating speed which Behm et al. (2005) found has not been proven as the limiting factors same as in a study of Krauser et al. (2012).

Both parameters, the explosive strength of lower limbs and dynamic balance have an influence on the running speed. From the all running tests have the highest consistency with the explosive strength of lower limbs tests the run to 10m test, which was proven statistically (F = 9,181; p<0,01), by intercorrelation (p<0,05), and practically (f2 = 0,706). One of the significant predictors of running speed found in our study was the performance in the vertical jump with countermovement test, where we found its significant influence on the level of running speed measured in 10 meters sprint (p<0,01) which correlates with results of Smirniotou et al. (2008), Brechue et al. (2010), Harris, Cronin, Hopkins and Hansen (2008), but do not match with the study results of Chelly et al., (2010). Another significant predictor which influence the running speed found in our study was the muscle performance measured in Squat Jump test. We found that the measured performance in Squat Jump mainly influences the level of running speed measured in 10 meters skating sprint (p<0,05). Same results were achieved by Young et al., (1995), Alexander (1989) a Nesser et al. (1996).The significant influence was also shown between the performances in the standing long jump and 5-15-5m test (p<0,01). Same results were achieved in studies of Brechue et al. (2010) and McCurdy et al. (2010).

Last significant predictors of running speed that we measured in our study were measured in the Y-Balance test. A significant relation was measured between the 5-10-5 run test and Y-Balance left foot (p<0,01) and also Y-Balance right foot (p<0,01) which is the same as in the study of Bayraktar (2017). As it was expected, both parameters - explosive strength of lower limbs and dynamic balance have an influence on running speed.

Conclusion

In this study, the hierarchy of limiting factors of hockey performance in skating and running tests was created through relation analysis. The assumption about the influence of explosive strength of lower limbs and dynamic balance to the performance in skating and running tests was confirmed only in maximal muscle performance, vertical jump and standing long jump. The differentiated hierarchy of factors according to the test difficulty and their performance on the ice and on dry land was proven. From the indicators of explosive strength of lower limbs has the decisive part on the explanation of skating and running performance the test of muscle performance of lower limbs, vertical jump with countermovement and standing long jump. Standing long jump tests from the left and right foot has the minimum share. Tests of dynamic balance on both foot shows as limited only at 5-10-5 meters running test. From all skating, tests have the highest consistency with tests of explosive strength of lower limbs the 5-10-5m test. From running tests have the highest consistency with the test of explosive strength of lower limbs the run test to 10 meters. In both cases, the partial shares of individual parameters are in positive relation according to the skating and running performance. These findings reaffirmed the importance of speed-strength assumptions of lower limbs as the factors limiting the skating and running speed in the sport structured preparation of hockey players. Differentiated hierarchy of factors is closely related to the difficulty of tests and their performance on the ice and on dry land and reflects the current level of physical performance of hockey players in the youth category.

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