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EFFECT OF SHORT-TERM BALANCE TRAINING
ON POSTURAL STABILITY IN ICE HOCKEY PLAYERS

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ABSTRACT

Postural stability is one of latent factors affecting game performance of an individual to a certain extent. The presented study deals with monitoring changes of postural stability in ice hockey players after eight week's balance training.

The screened sample consisted of junior category ice hockey players divided into experimental (n = 8) and reference groups (n = 8).

Postural stability was measured using a stabilographic method on the AMTI AccuS-wayPLUS force platform. The level of postural stability was assessed in three tests, namely bipedal stance with and without sight control and bipedal stance with reduced proprioception using the parameters of 95% confidence ellipse, path of CoP and mean velocity of CoP.

The level of monitored stability parameters did not indicate any significant differences between the groups in any of the tests at the level of significance $\alpha = 0.05$. Comparing postural stability of the experimental group between pre-test and post-test showed significant differences in the test without sight control and the test with reduced proprioception in l_{CoP} and v_{CoP} parameters (Z = 2.1004; $\alpha < 0.05$). Regarding the reference group, no significant changes of the level of postural stability between the pre-test and post-test were found in any of the parameters (Z = 0.3652 to 1.8257; $\alpha > 0.05$).

Keywords: sport training; balance exercises; posturography; AMTi; CoP

INTRODUCTION

Ice hockey is a fast, dynamic and invasive sport with a broad membership base. Sport performance in ice hockey consists of complex playing and skating skills. Skating in ice hockey is a complex motor skill (Bracko, 2004) and professional coaches, general managers and scouts consider skating skills a significant factor for selection of players for the team (Hansen & Reed, 1979). Skating is characterised by acyclic movement structure which consists of artificial movements (Pavliš & Perič, 2003) in terms of the structure of basic locomotion.

The level of skating skills is determined by mastering skating techniques and the level of stability. Skating in ice hockey is an automatized, subconscious process while consciousness is more involved in searching and assessing an optimal solution of the incurred playing situation. Practising skating technique is a domain of training process starting with children's categories; Pavliš & Perič (2003) suggest that it should account for up to 80% of training time; however, it also is necessary to develop skating technique in further stages of the training process, as well.

The basis of each movement is maintaining posture which the movement stems from (Trew & Everett, 1997; Véle, 1997). Figure skating and ice hockey belong to sports, in which the biomechanic stability required to maintain balance is limited by narrow base of support (Zemková, 2011). In addition, Braco (2004) points out the complexity of ice hockey in terms of high demands on coordination and repeated muscle load with a short rest interval. A narrow blade also causes strenuous eccentric muscle work and proprioceptive control in order to maintain stability (Humble, 2003; Li, 2007).

Equilibrium, postural stability and balance have not been clearly defined yet. A number of ambiguities are connected not only with terminological models but also with diagnostic methods, instrumentation capabilities, data processing and interpretation of results (Čech & Junger, 2012). Balance is often taken for granted and its importance is overlooked, even though it is one of the most important aspects in ice hockey (Stamm, 2001). Available literature provides only limited information on the effect of exercises on dynamic stability (Zemková, 2011) or the effect of balance exercises on motor skills of athletes (Hrysomallis, 2011). Therefore, we believe it is important to deal with the issue of increasing the level of postural stability in the process of sport training outside the ice rink. More and more coaches discuss the possibilities of strengthening deep stabilization and postural systems using balance exercises performed with one's own body weight or with the use of external supplementary resistance. However, in ice hockey theory, we may see a deficit of knowledge in the field of training process.

PURPOSE

The purpose of this study was to assess the effect of eight-week's exercise programme on the level of postural stability in ice hockey players.

METHODS

A total of 40 junior category ice hockey players participated in this research. However, the presented results includes only 16 players as the other players did not complete all measurements due to various reasons (transfer to another club or to another age category, sickness at the time of output measurements).

The research was carried out on a sample of players from HC Košice who won the title of Master of the Slovak Republic in their age category in the previous competitive season. The results of the research are related to performance of the players (n = 16) who completed both input and output measurements. Before exposure to the assigned stimulation,

players were divided in experimental and control groups S1 and S2 according to the head coach's instructions. At the time of the initial measurement, the decimal age of S1 group (n = 8) was 15.8 ± 0.6 years (x ± s), and S2 (n = 8) 15.7 ± 0.4 years. Basic somatic characteristics of both groups are listed in Table 1.

Table 1. Basic somatic characteristics of the screened sample

	Experimental group				Control group			
	Age	Body weight	Body height	BMI	Age	Body weight	Body height	BMI
$\bar{x}$	15.8	68.1	177.9	21.5	15.7	70.0	180.5	21.5
S	0.6	4.8	3.8	1.6	0.4	6.6	5.6	1.1

Legend: $\bar{x}$ – mean; s – standard deviation; BMI – body mass index

In terms of the phases of the annual training cycle, research was carried out in the period of intensive fitness training outside the rink. An independent variable affecting postural stability was an exercise programme consisting of dynamic power exercises especially with the use of unstable surfaces (bosu, balance boards, balance pads, overballs, expanders, medicine balls). The exercise programme was completed only by players from the experimental group (S1). Exercises on unstable surfaces represented 20% of net workout time of two training sessions in a week under the guidance of a fitness coach. Participants performed different exercises each week. The members of the control group (S2) practised traditional methods commonly used in the club. Traditional training sessions included exercises in a gym, fitness workouts (spinning, running, inline skating), obstacle courses and imitation hockey exercises.

To assess postural stability, we used a posturography method of measurement on a force platform. Each of the players, regardless of the group which he belonged to, completed three tests of postural stability marked as T1, T2 and T3 in input and output diagnostics. T1 measurement consisted of a bipedal stance with feet together on the force platform with sight control; in T2 participants performed a bipedal stance with the feet as wide as the pelvis with elimination of visual analyser and in T3 a bipedal stance with the feet as wide as the pelvis with reduction of proprioceptive perception and with a sight control (stance on a 10 cm high foam surface). During measurements with sight control (T1 and T3), participants concentrated on a selected visual point located on the wall at the level of their eyes at a distance of four meters. Each of these measurements lasted for 30 seconds and the tested subjects performed them in a row with a rest interval necessary for changing position or preparation of changed conditions, respectively. The level of postural stability was assessed on the basis of parameters related to the Centre of Pressure (CoP). The participants' CoP was measured on AMTI's AccuSwayPLUS force platform (© Advanced Mechanical Technology, Inc., 2002). Digital output from the platform was recorded by AMTI's NetForce software, the recording frequency of which is 50 Hz. The software for identification of CoP location uses algorithms from the related variables, i.e. parameters of forces acting on the platform (Fx, Fy, Fz) and moments of these forces (Mx, My, Mz). The recording was further processed by means of BioAnalysis software which provides not only digital outputs in the form of statistics but also 14 graphical outputs.

To analyse the effect of the intervention programme, out of the spectrum of parameters we selected three basic parameters which characterise the movement of CoP during the measurements; namely path of CoP (l_{CoP}), mean velocity of CoP (v_{CoP}) a 95% confidence elipse ($EA_{95\%}$).

Individual performances of participants from S1 and S2 groups were further processed using both quantitative and qualitative procedures. Data were processed using methods of mathematical statistics in the Statistica 10 programme. From the perspective of the nature of data (low number of subjects, normality of data distribution), for statistical evaluation we selected the median (ME) from the measurements of central tendency and interquartile range (IQR) and quartile deviation (QD) from the measurements of variability. To monitor the effect of intervention on the level of postural stability parameters we used non-parametric methods of mathematical statistics. In the case of evaluation of the statistical significance of differences between S1 and S2 groups we used the Mann-Whitney U test for independent samples. To assess the significance of differences in the level of postural stability between pre-test and post-test within individual groups the Wilcoxon test for dependent samples was used. Subsequently, the results were evaluated at the level of significance $\alpha = 0.05$.

RESULTS AND DISCUSSION

A number of studies dealing with sport performance and training in ice hockey have been published. However, most of them focus on biomechanical parameters of skating (Braco, 2004; Humble, 2003; Maclean, 2012), kinematic analysis (Marino & Drouin, 2000; Upjohn et al., 2008; Stidwill, 2009) or sport performance (Brocherie et al., 2005; E. Maclean, 2012). There is a deficit of knowledge in the field of development of stability in ice hockey even though Zemková (2011) states that fast adaptation of stability in and after sport performance is considered an important skill in sport practice.

Table 2. Descriptive statistics of stability parameters of S1 group (n = 8)

		T1			T2			T3		
		ME	IQR	QD	ME	IQR	QD	ME	IQR	QD
$EA_{95\%}$	Pre-test	0.968	0.937	0.487	2.987	3.712	1.856	2.488	4.038	2.019
	Post-test	0.913	0.281	0.141	2.750	1.322	0.661	2.326	1.218	0.609
v_{CoP}	Pre-test	0.950	0.152	0.076	2.917	0.367	0.184	3.146	0.987	0.494
	Post-test	0.921	0.212	0.106	2.671	0.594	0.297	2.942	0.846	0.423
l_{CoP}	Pre-test	28.500	4.559	2.280	174.990	22.019	11.010	188.780	59.217	29.608
	Post-test	27.630	6.377	3.188	160.240	35.598	17.799	176.480	50.760	25.380

Legend: T1 – bipedal stance with feet together with sight control; T2 – bipedal stance with the feet as wide as the pelvis without sight control; T3 – a bipedal stance with the feet as wide as the pelvis with reduction of proprioceptive perception; ME – median; IQR – interquartile range; QD – quartile deviation; $EA_{95\%}$ – 95% confidence ellipse; v_{CoP} – mean velocity of CoP; l_{CoP} = path of CoP

Table 3. Descriptive statistics of stability parameters of S2 group (n = 8)

		T1			T2			T3		
		ME	IQR	QD	ME	IQR	QD	ME	IQR	QD
$EA_{95\%}$	**Pre-test**	1.154	0.844	0.422	2.701	2.472	1.236	2.908	2.339	1.170
	Post-test	0.916	0.457	0.229	2.033	0.354	0.177	2.386	1.218	0.434
v_{CoP}	**Pre-test**	0.898	0.168	0.084	2.850	0.299	0.149	3.109	0.703	0.352
	Post-test	0.807	0.235	0.118	2.336	0.677	0.339	2.232	0.846	0.241
l_{CoP}	**Pre-test**	26.913	5.017	2.510	170.970	17.907	8.953	186.540	42.191	21.906
	Post-test	24.197	7.064	3.532	140.060	40.637	20.319	133.910	50.760	14.440

Legend: T1 – bipedal stance with feet together with sight control; T2 – bipedal stance with the feet as wide as the pelvis without sight control; T3 – a bipedal stance with the feet as wide as the pelvis with reduction of proprioceptive perception; ME – median; IQR – interquartile range; QD – quartile deviation; $EA_{95\%}$ – 95% confidence ellipse; v_{CoP} – mean velocity of CoP; l_{CoP} = path of CoP

Table 2 and Table 3 present results of descriptive statistics of the selected parameters characterising postural stability of experimental and control groups. On the basis of these results we can state that the monitored stability parameters improved in both experimental (S1) and reference group (S2) during the training process.

Considerable improvement in stability, in terms of middle values, was recorded in members of the control group (S2). These findings indicate the uselessness of implementation of a short-term balance exercise programme in the sports training of young hockey players. On the other hand, Braco (2004) mentions that if we want to prepare an effective training programme, players should be confronted with such conditions which control their movement during a game, e.g. to include enhancing exercises for stick work technique in the balance exercises as it was in our case.

Analysis of results characterising variability of the measured data (QD, IQR) in l_{CoP} and v_{CoP} parameters indicate that in the case of the reference group (S2) we recorded higher values than in the experimental group. Therefore, we believe that the achieved middle value of ME in the S2 group could have been partially influenced by the extreme performance of participants in terms of greater heterogeneity of performance in post-test measurement or skewness of the measured data distribution (data not published), respectively.

Véle (1997) mentions that exclusion of one of the three main components (visual, vestibular and proprioceptive) providing afferent information on stability for regulatory organs should not be reflected in deterioration of stability. However, research studies confirm crucial importance of proprioception for regulation of stability (Le, 2007), which is in accordance with the results of our study. In the measurement with reduced proprioception perception (T3) we recorded the highest middle values in comparison to other tests, which means deterioration of postural stability.

Table 4. Comparison of the level of postural stability parameters recorded before and after intervention (Wilcoxon test)

	S1					
	T1		**T2**		**T3**	
	T	**Z**	**T**	**Z**	**T**	**Z**
EA$_{95\%}$	13.0	0.7001	10.0	1.1202	13.0	0.7001
v$_{CoP}$	14.0	0.5601	3.0	2.1004*	3.0	2.1004*
l$_{CoP}$	14.0	0.5601	3.0	2.1004*	3.0	2.1004*
	S2					
EA$_{95\%}$	1.0	1.4606	4.0	0.3652	1.0	1.4606
v$_{CoP}$	4.0	0.3652	1.0	1.4606	0.0	1.8257
l$_{CoP}$	4.0	0.3652	1.0	1.4606	0.0	1.8257

Legend: T1 – bipedal stance with feet together with sight control; T2 – bipedal stance with the feet as wide as the pelvis without sight control; T3 – a bipedal stance with the feet as wide as the pelvis with reduction of proprioceptive perception; T – Student's T-score; Z – Z-score; EA$_{95\%}$ – 95% confidence ellipse; v$_{CoP}$ – mean velocity of CoP; l$_{CoP}$ – path of CoP; *p < 0.05.

Based on results in Table 4, we can conclude that in the case of the control group we did not find any statistically significant changes in the level of the monitored parameters of postural stability between input and output measurements in any of the tests. Statistical analysis further indicated a positive effect of the training process on the performance of participants from the experimental group when in T2 and T3 tests we recorded significant differences in the level of path of CoP (l$_{CoP}$) and mean velocity of CoP (v$_{CoP}$). Concerning the third examined parameter EA$_{95\%}$, no significant changes between input and output measurements were recorded. We suppose it can be caused by a high level already achieved in the input measurement (ME T2 = 2.98 cm^2; ME T3 – 2.48 cm^2), which participants managed to slightly improve in the output measurement (ME T2 = 2.75 cm^2; ME T3 – 2.32 cm^2). In T1 no significant changes in the examined parameters of postural stability were found. We think that the reason could be in inadequacy of the motor test.

Table 5 provides the results of statistical significance of differences in the level of postural stability between performances of the experimental and control group. In any of the compared data pairs we did not record significant differences at the level of significance α = 0.05.

Based on the structure of the training process which participants completed there are several aspects which could have caused the obtained results. The first is inclusion of imitation skating exercises and obstacle courses in the usually used training model. These methods impose substantial requirements on agility and coordination abilities of athletes which can positively influence stability of the stance.

Table 5. Comparison of the level of postural stability parameters between S1 and S2 groups in input and output measurements (Mann-Whitney U test)

	S1					
	T1		**T2**		**T3**	
	T	**Z**	**T**	**Z**	**T**	**Z**
$EA_{95\%}$	22.0	0.194	24.0	−0.065	23.0	−0.065
v_{CoP}	18.0	0.711	18.0	0.711	19.0	0.581
l_{CoP}	18.0	0.711	18.0	0.711	19.0	0.581
	S2					
$EA_{95\%}$	1.0	1.461	4.0	0.365	1.0	1.461
v_{CoP}	4.0	0.365	1.0	1.461	0.0	1.826
l_{CoP}	4.0	0.365	1.0	1.461	0.0	1.826

Legend: T1 – bipedal stance with feet together with sight control; T2 – bipedal stance with the feet as wide as the pelvis without sight control; T3 – a bipedal stance with the feet as wide as the pelvis with reduction of proprioceptive perception; T – Student's T-score; Z – Z-score; $EA_{95\%}$ – 95% confidence ellipse; v_{CoP} – mean velocity of CoP; l_{CoP} – path of CoP

Moreover, especially in that period, training sessions focused on development of strength abilities of all muscle groups were applied. Development of strength abilities is, particularly in the older population, considered a suitable means for positively influencing the level of postural stability.

The training programme was applied during eight weeks in the period of intensive fitness preparation when the players performed two-phase training load in 8–12 training sessions during a weekly micro-cycle. The intervention programme made up only 20% of two training sessions. Therefore it is possible that the effect of balance exercises could have been partially affected by inhibited endogenous and exogenous changes caused by other forms of the load applied. Similarly, the length of intervention in the experimental group could be another reason why exercises were not reflected in greater measure. However, authors are not consistent in the opinion on the time interval required to make the independent variable reflect in the improvement of the level of the observed parameters. Zemková (2011) in her meta-analytic study described the usage of 3, 4, 8 and 12 week intervention programmes focused on the development of postural stability.

CONCLUSION

The presented study does not have a character of generalised results as basic requirements for randomness and representativeness of the research group and its size were not met. However, we believe that the results will contribute to enrichment of knowledge in the field of ice hockey and that they will also be usable for sport practice.
Based on the above described results we can state that:
– no statistically significant difference in the level of postural stability between the experimental and control group was found in any of the measurements,

- in the case of the experimental group, after intervention, statistically significant differences in the level of parameters indicating the level of postural stability were observed between the test without sight control and the test with reduced proprioception,
- in the control group, no significant changes in the level of postural stability between pre-test and post-test were detected,
- the performed balance exercises had a positive impact on homogeneity of results of the experimental group.

Ice hockey is a fast, popular sport, performance in which is determined by a number of manifestation and latent variables. Postural stability as one of the main latent variables is thus an important factor influencing not only skating technique; therefore it can also influence individual playing performance to a certain extent. This is the reason why we believe that inclusion of balance exercises in the training process is more than desirable. We do not state that a high level of postural stability is the only crucial factor in the level of player's performance. However, further research in the form of relationship analyses between this latent variable and skating technique or skating speed would certainly enrich not only the theoretical part of science but practice as well.

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