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Functional state of the musculoskeletal system and injury rate among ice hockey players

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Abstract: Injuries in hockey need not be primarily caused by physical contact. The second category may include injuries caused by inappropriate loading, which in turn affects the state of the musculoskeletal system during matches or training sessions. As a result of this, in the 2018-19 season, two elite senior hockey teams were tested for the functional state of the musculoskeletal system, which was also related to players' ice time and the rate of injuries during the season. The sample included 30 hockey players (15 forwards, 12 defensemen, and 3 goalkeepers). Testing was carried out at the beginning of the season. Players performed the Y balance test and underwent FMS screening. The results showed that the shoulder region is most susceptible to injury. The hockey players suffered from hamstring muscle imbalance. Active ice time can be considered a determining parameter which can cause injury. However, its relationship with other variables has not been confirmed.

Keywords: Ice hockey, Training, FMS, Y balance test

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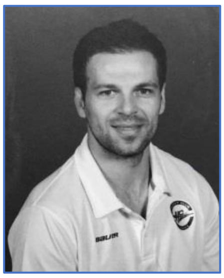

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1. Introduction

Ice hockey is one of the fastest contact sports games, which places immense physical and mental demands on players, with a risk of injury as an integral part of the game [1], especially to the head, face, and neck [2] sustained in both sexes [3]. Injury rates in competitive ice hockey range from 13.8 to 121/1000 player-game hours, depending on factors such as the league of play and exposure estimate [4]. In Canada, there is a regularly updated registry of serious spinal injuries sustained while playing hockey. This registry shows that 243 spinal injuries were reported for the period 1966–1996. The registry is updated by physical of various specializations who add cases to the injury registry [5]. Ice hockey has become a significantly faster sport, and prevention and early assessment of the musculoskeletal system injuries is one of the health-determining factors. Sports experts have been administering a battery of tests to assess the fundamental movement patterns for the identification of limitations and asymmetries. This enables to recommend a targeted "therapy" for the purpose of acquiring optimal movement stereotypes [6-7]. Sports specialization and hockey training on the one hand develops the special skills of players, but on the other hand, due to one-sided load, there is a high probability of developing muscle imbalance. This manifests itself as a certain mismatch of muscular "cooperation" that arises from the incorrect distribution of muscle tension. Consequently, this failure negatively affects the posture and movement of the particular segment. The muscular system "lies at the crossroads" where the effects from the central system (brain, spinal cord) and the peripheral effects (skin, subcutis, joints) converge. These are therefore external and internal impacts. Through the CNS, the muscular system is functionally linked to other systems. Each muscle is an anatomical unit from which muscle function can be derived. Muscle activity results in mechanical movement. The mechanics of the player's movement on the ice depends on the acquisition of skating skills and individual game skills while working with the stick [8].

As far as injuries are concerned, it is important to classify injuries sustained. In its game injury report forms, the International Hockey Federation categorizes injuries as follows: 1. any injury sustained in a practice or a game that prevented the player from returning to the same practice or game; 2. any injury sustained in a practice or a game that caused the player to miss a subsequent practice or game; 3. a laceration that required medical attention; 4. all dental injuries; 5. all concussions; 6. all fractures [9]. This issue is the responsibility of team physicians who determine the way forward. The issue of injuries is an extensive and complicated topic and often concerns players at an early age [10]. The variety of injuries sustained and their rate of incidence in ice hockey have not been sufficiently addressed in the studies conducted to date.

2. Methods

The purpose of the study was to assess the functional state of the musculoskeletal system in relation to injury rate and ice time among ice hockey players. The participants were 30 ice hockey players who play for the elite Slovak ice hockey clubs. Table 1 shows the basic characteristics of the participants. The sample included players who play for the HK Poprad ice hockey club: 6 forwards, 5 defensemen, and 1 goalkeeper, and the HC Košice ice hockey club: 9 forwards, 7 defensemen, and 2 goalkeepers.

The purpose of the test is to maintain the one-legged standing position and to push the reach indicator as far as possible in three directions: anterior, posteromedial, and posterolateral. The upper quarter test assesses musculoskeletal stability and mobility. Core stability and thoracic mobility help subjects to push the reach indicators as far as possible without losing balance. When in the push-up position and with feet shoulder-width apart, the subject has to push the reach indicator as far as possible in the following directions: medial, inferolateral, and superolateral. After the subject pushed the reach indicators in all three directions in both tests, he or she had to return to the starting position. The overall scores for upper and lower quarter tests were expressed as the composite score. Functional movement screen (FMS) assesses mobility and stability, identifying correct and incorrect movement patterns. The FMS is a screening tool used to evaluate 7 fundamental movement patterns. Each of the patterns is scored from 0 to 3 points, with the sum creating a total score, which can be used to recommend a targeted "therapy" for the acquisition of more optimal movement stereotypes [6]. The assessment also included the body composition analysis using the InBody 230 body composition analyzer, which uses bioelectrical impedance. The collected data were processed both graphically and practically. We used median as the measure of central tendency, which divides the gradually sorted data according to their size into two equal halves.

Table 1 Sample characteristics

	HC Košice *Mdn*		HK Poprad *Mdn*	
n	**18**		**12**	
Age (years)	26.4		30.3	
Body height (cm)	184		185.1	
Body mass (kg)	85.6		92.2	
Muscle mass (kg)	43.8		47.5	
Fat mass (kg)	12.9		14.1	
Stick holding	Left	Right	Left	Right
	12	6	9	3

Note. *n - sample size*

When processing the data collected, we used the qualitative methods, namely deduction, analysis, and comparative analysis. The physical units measured were converted to interval-based Z-scores [11]. We used the Spearman's rank order correlation to determine relations between two quantitative variables.

3. Results and Discussion

The fundamental movement patterns assessed using the FMS provide a subjective assessment of the stereotypical performance of prescribed movements. The selected movements from the functional movement system help to assess joint stability and mobility, including shortened muscle chains in their dynamic manifestation. The total score achieved lower than 14 indicates an increased risk of injury [12]. Table 2 shows mean point values for players of particular ice hockey teams. The results show that shoulder mobility is the most critical body segment. One player sustained a shoulder injury after being hit by an opposing team's player.

Only 3 players, namely one defenseman and 2 forwards who just started playing senior hockey, achieved the scores of 3 points. Their average age was 21.6 years. Ice hockey players have to maintain their trunks laterally flexed, protracting their shoulders, which is caused by stick holding. In NHL, most goals are scored from the area of 10 to 20 feet from the goal, providing one of the most effective zones for snapshots and slapshots [13]. Mechanics of movement and functional state of the musculoskeletal system rely primarily on the stick holding and the associated transfer of forces acting on particular body segments.

The players of HK Poprad had to shoot 2449 times at the goal to score 198 goals, while the players of HC Košice had to make 2301 shots to score 206 goals. The lower-body segment that is most susceptible to injury is the hamstring area. The shortening of hamstring muscles limits the range of movement, especially among goalkeepers. One goalkeeper achieved the score of 1 point in the active straight leg raise test. In the course of the regular season, the same goalkeeper sustained a knee ligament strain, which was not caused by physical contact but rather by regular activity within the goal crease.

As the skating movements are highly specific, players performed the lower quarter Y balance test (Figure 1). There were no differences in functional asymmetries, which would indicate the risk of lower-body injuries. The difference between right- and left-limb composite scores larger than 4 cm was not recorded. As the previous experience has shown, we may conclude that this state in adulthood may not be corrected without adequate compensation as early as youth categories [14-15]. The differences between upper-limb composite scores were 0.3 cm in HK Poprad players and 0.8 cm in HC Košice players (Figure 2). In both cases, the differences were minimal, which shows a high level of conditioning, especially in the trunk region, associated with the transfer of movements to the upper-body segment. From the standpoint of more extensive research, an interesting finding is that players showed a higher degree of balance between the right and left upper body compared with the lower body. This may be caused in part by systematic strengthening of trunk muscles, which took place in both teams in the regular season concerned.

Table 2 Assessment of movement patterns

FMS – movement patterns	HK Poprad (*n* = 12)			HC Košice (*n* = 18)		
	Mdn			*Mdn*		
	RL	LL	Score	RL	LL	Score
Deep squat	-	-	2.5	-	-	2.2
Hurdle step	2.2	2.2	2.2	2.2	2.2	2.1
In-line lunge	2.5	2.4	2.5	1.8	2	1.8
Shoulder mobility	1.7	1.7	1.7	2.1	1.9	1.7
Active straight leg raise	2.8	2.8	2.7	2.2	1.9	1.9
Trunk stability push-up	-	-	2.6	-	-	2.3
Rotary stability	2.2	2.1	2.1	2	2	2
Total score			16.3			14

Note. *FMS – Functional movement screen; n – sample size; RL – right limb; LL – left limb*

Figure 1 Y balance test – lower limbs (*n* = 30).

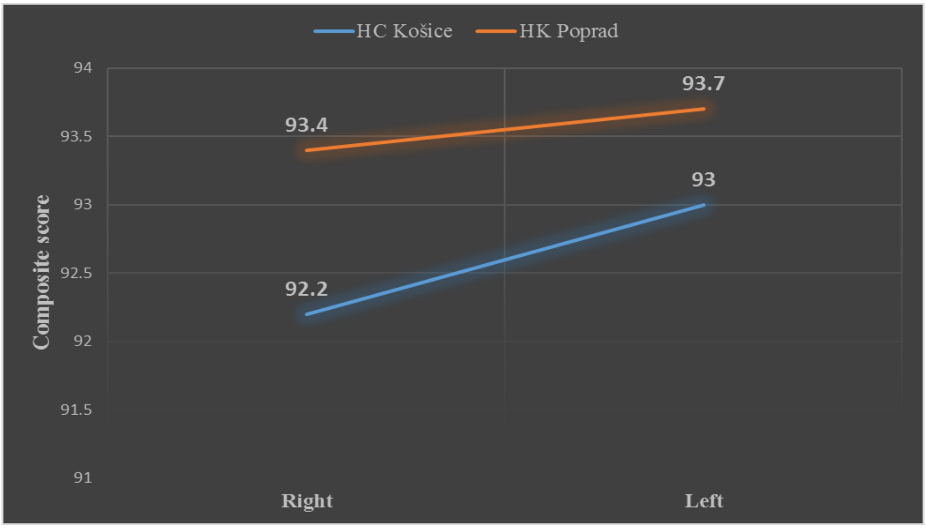

Figure 2 Y balance test – upper limbs (*n* = 30).

Table 3 Differences between clubs during the regular season

2018-19 season	HC Košice	HK Poprad
Games played	57	57
Games won	32	28
Games won in overtime	4	9
Games lost	16	17
Games lost in overtime	5	3
Number of goals	190:135	168:147
Points	109	105

Table 4 Correlation between parameters

S. No	1. Ice time	2. FMS	3. YBT RL	4.YBT LL	5.YBT LA	6.YBT RA
1.	-					
2.	0.16	-				
3.	0.03	0.11	-			
4.	-0.08	-0.03	**0.89**	-		
5.	-0.23	0.21	0.22	0.11	-	
6.	-0.08	0.17	0.12	0.05	**0.84**	-

Note. FMS – Functional movement screen; YBT RL – Y balance test for the right leg; YBT LL – Y balance test for the left leg; YBT LA – Y balance test for the left arm; YBT RA – Y balance test for the right arm

Table 3 shows the number of games played and ice time for both ice hockey teams during the 2018-19 regular season. Overall, the teams played against each other five times, and HK Poprad won 3 out of 5 games.

In the first play-off round, both teams played 6 games, i.e. 3 home games and 3 away games each, in the course of 10 days. The players of HK Poprad who were more successful won 4:2. The overall comparison of the administered tests showed a 0.1 cm difference in the Y balance test between the teams, which is an insignificant difference that may have been caused by the error of measurement. On the other hand, the difference in the FMS score between the teams was 2.3 points. In the course of the entire season, the players of HK Poprad and HC Košice spent an average of 693.3 and 665.7 minutes on the ice, respectively. The highest amount of ice time was recorded for goalkeepers who spent 2714 minutes on the ice on average. Of players other than goalkeepers, the highest amount of ice time was recorded for the HC Košice forward who spent 1135.4 minutes on the ice. According to the correlation analysis, we devised a theoretical construct of relationships between variables (Table 4).

There were no significant relationships between variables. Ice time is one of the determining factors, which may be used to assess the use of players in games. However, the situations that occur during games need to be taken into account, namely total even strength time, power play time, and short-handed time. This is all based on the number of shifts and team tactics. The results show that each of these variables carries a specific information value.

The injury rate in ice hockey may be caused by a variety of circumstances, which result from the league format, namely number of games played, ice rink dimensions and stadium facilities, especially boards and protective glass. The injury rates have increased over time in professional European leagues and college hockey, while decreasing in men's international ice hockey [4]. In the study on injuries in hockey, 528 injuries in 511 incidents were reported in 844 games. Additionally, 27 injuries occurred during the practices. Injuries involved the head and face in 210 cases, the lower body in 162 cases, the upper body in 115 cases, and spine or trunk in 41 cases. The knee was the most common lower body injury. Ankle and thigh injuries were the second and third most common lower body injuries. The shoulder was the most common location for an upper body injury. The fingers, wrist, and hand injuries were in the second, third and fourth place in upper body injuries, respectively [9]. The likelihood of injury caused by the specificity of ice hockey itself increases with the active time on ice. In the 2018-19 NHL season, the highest amount of time, 2188.45 minutes, was spent on the ice by a defenseman [16].

4. Conclusions

Injury prevention in ice hockey is based on the prevention based on the work of physicians, physical therapists, and conditioning coaches, who adapt training programs according to the needs of particular players. There is not much time for individual training during the regular season. In most cases, players engage in individual training when coming back from injury. The assessment of movement stereotypes also during the hockey season contributes to the prediction of increased risk of injury. The results show that players who participated in the study sustained mostly shoulder injuries. It is highly probable that these injuries are caused by the unilateral stick holding and physical contact during games. Of the entire sample of 21 players, who held their hockey sticks on the left side, most players suffered from restricted mobility on the right side of the body. Lower-body imbalance was recorded particularly for the hamstring muscles who are important for both knee stabilization and correct movement stereotypes. This analysis is to be extended further by examining how the functional state of the musculoskeletal system affects results of teams without injury assessment

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Informed consent

All participants gave written informed consents to participate in this study.

Conflict of interest

None of the authors have any conflicts of interest to declare.