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Lower limb dynamic stability in professional hockey players

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Abstract

Introduction. Ice hockey is one of the most popular sports that constitutes a physically demanding intermittent type of physical activity. It also requires an enormous amount of energy expended by the musculoskeletal system. The main objective of the study was to determine the dynamic stability of the lower limb in professional hockey players.

Methods. The Y-balance test was chosen to measure the dynamic stability of lower limb. In addition, an electronic questionnaire was applied to obtain data associated with the knee joint injuries.

Results. The mean value of the composite score for the right lower limb was 1.07 (± 0.10). The minimum value of the composite score for the right lower limb was 0.88, and the maximum value equalled 1.25. The mean value of the composite score for the left lower limb was 1.08 (± 0.11). The minimum value for the left lower limb was 0.90, and the maximum equalled 1.27.

Conclusions. Dynamic stability in the tested group of professional hockey players was shown to be adequate; however, further studies will be needed to determine the optimal values of the Y-balance test in the prevention of injuries in hockey players.

Key words: dynamic stability, hockey, prevention, Y-balance test

Introduction

Ice hockey is a popular sport, one of the most watched team sports in the world [1]. It constitutes an intermittent type of physical activity [2]. Buchtelová et al. [3] emphasize that ice hockey requires an enormous amount of energy expended by the musculoskeletal system. Several factors affect performance in professional sports [4]. The most frequent factor is injury, which is the most frequently discussed issue [5]. Hockey is a collective sport and a contact sport, with an increased risk of being injured by another player. Injuries influence not only the athletic performance of the player, but also the entire team. Absence has considerable consequences for the team but especially for the player himself. A systematic preparation and compensation for unilateral load, which is very important, will contribute to the proper development of the individual and thus reduce the risk of injury caused by overload or inappropriate movement patterns [6–9]. The load that affects the joint is a result of external forces and muscle forces that are needed to maintain posture and ease movement [10]. Ligament forces are internal forces that are generated in response to movement or external loading of a joint. Owing to the anatomical and structural complexity of the knee joint, the forces acting on the joint are very difficult to measure [11]. Forces that act at the synovial junction can be divided into compression, friction, and shear forces. The compressive force is distributed on the contact surface of the *junctura synovialis* to achieve the tension in the given structures.

Ice skating is one of the most important skills in ice hockey. Therefore, a correct understanding of the biomechanics of ice skating is very important. Ice skating at a constant speed is a 2-phase movement that is divided into a support and a swing phase. Skating is understood as a new type of locomotion because the alignment of the lower limb is not in the same direction as the movement of the body, e.g., when walking or running. The ice hockey player moves by creating a reactive force on the ice that is perpendicular to the longitudinal axis of the skate blade. To generate this force, an external rotation is required with simultaneous extension of the hip joint, whereby the skater leans on the inner edge of the skate blade. Skates are an essential part of skating because the hockey player can use various friction properties of the ice surface. Hip abductors and extensors, along with the flexors and abductors responsible for hip stabilization and braking, are the main muscle groups involved in movement during ice skating [12]. The dynamic stability of the lower extremities plays a crucial role in ice skating and athletic performance [13, 14].

Our study focuses on measuring, using the Y-balance test (YBT), the dynamic stability of the lower limb in professional hockey players.

Subjects and methods

Participants' characteristics

The research group consisted of 30 professional hockey players with a mean age of 26 years (± 4.91); the youngest participant was 18 years old and the oldest one was 36 years old. The median age was 25.77 years. The mean height of the players was 188 cm (± 6.77); the lowest subject measured 173 cm and the tallest one measured 202 cm. The median height equalled 187.5 cm. The players had a mean weight of 92 kg (± 8.61); the lightest participant had 80 kg, and the heaviest one 113 kg. The median weight was 89 kg. The mean body mass index equalled 26.8 kg/m^2 (± 1.63), with the lowest value of 22.6 kg/m^2, the highest of 29 kg/m^2, and the median of 26.64 kg/m^2. Five ice hockey players were members of the highest professional hockey league in the world, the National Hockey League (NHL; 2 NHL players and

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3 players from the NHL farm). One player was a member of the Kontinental Hockey League and 24 were members of the highest Slovak league.

Research method

The research was carried out during the 2019/2020 season before the end of the regular season. To obtain the data for the investigation, YBT was chosen, which focuses on testing the dynamic stability of the lower limb. Additionally, we applied an electronic form in order to collect data associated with knee joint injuries.

Characteristics of the questionnaire

The main purpose of the questionnaire was to obtain data from players regarding knee injuries. The questionnaire consisted of 15 questions and was distributed in an electronic form. There were 11 multiple choice questions and 4 short-answer questions. The first 5 questions focused on personal parameters. The sixth and seventh questions referred to injuries. The eighth question divided the players into 2 groups: with and without injured knee joint. The other questions found out and requested detailed specifications of knee injuries of the individual players who had experienced similar injuries in the past.

Testing method

YBT is a simple and reliable test used to measure dynamic stability. It is applied as a preventive examination of the musculoskeletal system to determine the risk of injury [15]. YBT was developed to refine and modify the Star Excursion Balance Test. It is used to assess the stability and dynamic balance of the athlete [16]. It requires strength and flexibility along with proprioceptive sense. YBT evaluates the stability of an athlete by testing their postural system in 3 directions: anterior, posteromedial, and posterolateral. The YBT equipment consists of a base platform to which are attached 3 arms in the test directions. The rear arms are positioned at a 135° angle to the front arm, and the rear arms form a 45° angle. Arms are marked with a scale in centimetres, which also includes a sliding indicator that is used to determine the exact distance reached.

Each participant performed a warm-up before the measurement. The warm-up should be consistent with the biomechanical and physiological nature of the test. Between the warm-up and the testing itself, the participant had a 3–5-minute recovery break.

Measurement rules

The players wore simple clothing so as not to restrict the movement, then took the position in the centre of the test platform and put a bare foot to the test red line.

The testing directions were as follows:
- anterior direction, right lower limb;
- anterior direction, left lower limb;
- posteromedial direction, right lower limb;
- posteromedial direction, left lower limb;
- posterolateral direction, right lower limb;
- posterolateral direction, left lower limb.

The participants were informed about the measurement procedure. Each individual took the test position and moved the indicator in the test direction and returned to the default position. The range of the distances should be recorded with an accuracy of 0.5 cm. The test movement was repeated with both lower limbs 3 times. After 3 successful attempts, the participant continued to another test direction.

Invalid attempt

An invalid attempt is considered when the participant loses contact with the movable indicator, kicks to the indicator, uses the indicator as support, loses their balance and touches the ground, or does not keep their foot on the test platform.

Valid attempt

A valid attempt is considered when the participant starts correctly and then returns to the default position in accordance with the rules.

Evaluation

YBT is evaluated as a composite score:

absolute reach distance (cm) = (reach 1 + reach 2 + + reach 3) / 3 relative (normalized) reach distances (%) = = absolute distance

Statistical analysis

We used descriptive statistics in the study. Furthermore, mean value testing, median, standard deviation, minimum, and maximum were determined. A 2-sample *F*-test was used for variance to assess statistical significance. On the basis of the *F*-test results, a 2-sample *t*-test for equal variances was employed. The chosen level of significance α was 0.05 for all monitored parameters.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethics Committee of the Slovak Medical University.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Evaluation of the Y-balance test

The mean value of the length of the right lower limb was 98.5 cm (± 8.71). The minimum length of the limb was 78.5 cm, and the maximum equalled 119 cm. The median was 98.5 cm. The mean value of the length of the left lower limb was 98.7 cm (± 8.85). The minimum length of the limb was 78.5 cm and the maximum equalled 119 cm. The median value was 99.5 cm.

Process of the dynamic stability of the lower limb test results by means of the Y-balance test, result value = absolute reach distance

The result values of the absolute distance in the anterior direction reached by the players with both lower limbs are presented in Table 1. The mean distance reached by the right lower limb was 75.73 cm (± 10.55). The minimum value for the right lower limb was 42 cm, the maximum was 97.50 cm,

Table 1. Test evaluation: absolute distance in all directions

Test direction	Mean value	Average difference	Min.	Max.	*SD*
Anterior RLL	75.73	–0.35	42	97.50	10.55
Anterior LLL	75.38		43.5	100	11.31
Posteromedial RLL	123	1.98	96	146	11.93
Posteromedial LLL	124.98		101	152	10.66
Posterolateral RLL	117.25	0.96	93	138	10.28
Posterolateral LLL	118.22		97	140	9.61

RLL – right lower limb, LLL – left lower limb

Table 2. Evaluation of composite reach distance

Test direction	Mean value	Average difference	Min.	Max.	*SD*
Composite score RLL	1.07	0.01	0.88	1.25	0.10
Composite score LLL	1.08		0.90	1.27	0.11

RLL – right lower limb, LLL – left lower limb

Table 3. Evaluation of relative reach distance in the anterior direction

Test direction	Mean value	Average difference	Min.	Max.	*SD*
Anterior RLL	0.77	0	0.40	0.99	0.11
Anterior LLL	0.77		0.41	1.01	0.12

RLL – right lower limb, LLL – left lower limb

and the median equalled 76 cm. For the right lower limb, the skewness was –0.66 and the kurtosis was 2.76. The mean reach distance of the left lower limb was 75.38 cm (± 11.31). The minimum value for the left lower limb was 43.5 cm, and the maximum was 100 cm. The skewness of the left lower limb was –0.30 and the kurtosis was 1.11. The median value equalled 74.5 cm.

The results of the absolute reach distance in the posteromedial direction are shown in the middle of Table 1. The mean value for the right lower limb was 123 cm (± 11.93). The minimum reached by the right lower limb was 96 cm, and the maximum was 146 cm. The median value equalled 123.5 cm. The mean value for the left lower limb was 124.98 cm (± 10.66). The minimum value for the left lower limb was 101 cm, and the maximum was 152 cm. The median value equalled 125.5 cm.

The mean distance reached by the right lower limb in the posterolateral direction was 117.25 cm (± 10.28). The minimum reach of the right lower limb was 93 cm, and maximum was 138 cm. The median value equalled 116.25 cm. The skewness of the right lower limb was –0.10, and the kurtosis was 0.04. The mean value reached by the left lower limb was 118.22 cm (± 9.61). The minimum value for the left lower limb was 97 cm, and maximum was 140 cm. The median value equalled 118.5 cm.

Process of the dynamic stability of the lower limb test results by the means of the Y-balance test, result value = composite reach distance

Table 2 shows the results of the composite reach distance. The mean value for the right lower limb was 1.07 (± 0.10). The minimum and the maximum values for the right lower limb equalled 0.88 and 1.25, respectively. The median was 1.09. Skewness and kurtosis of the right lower limb were –0.25 and –0.87, respectively. The mean value for the left lower limb was 1.08 (± 0.11). The minimum value for the left lower limb was 0.90, and maximum was 1.27. The median value equalled 1.09.

Table 3 shows the values of the relative reached distance in the anterior direction. The mean value for the right lower limb was 0.77 (± 0.11). The minimum value for the right lower limb was 0.40, and the maximum was 0.99. The median value equalled 0.78. The mean value for the left lower limb was 0.77 (± 0.12). The minimum and the maximum values for the left lower limb were 0.41 and 1.01, respectively. The median value equalled 0.76.

Subsequently, the reached distance in the posteromedial direction was measured. The mean value for the right lower limb was 1.25 (± 0.12). The minimum value for the right lower limb was 1.03, and the maximum was 1.46. The median value equalled 1.27. The mean value for the left lower limb was 1.27 (± 0.11). The minimum value for the left lower limb was 1.07, and the maximum was 1.51. The median value equalled 1.29.

Then, the distance in the posterolateral direction was determined. The mean value for the right lower limb was 1.20 (± 0.13). The minimum value for the right lower limb was 0.98, and the maximum was 1.44. The median value equalled 1.21. The mean value for the left lower limb was 1.21 (± 0.13). The minimum value for the left lower limb was 0.96, and the maximum was 1.49. The median value equalled 1.21.

Questionnaire evaluation

Question No. 8 allowed to find out how many players had experienced a knee injury; 21 participants responded that they had undergone a knee injury and 9 stated that they had not. Question No. 15 examined whether or not the injury had occurred repeatedly. Most of the players, specifically 18 (86%), reported that the injury had not recurred, while 3 (14%) said that it had occurred again.

Tables 4 and 5 compare a statistically significant difference at the level of $\alpha = 0.05$ between the dominant and non-

Table 4. *F*-test for 2-sample variances

Outcome	Dominant lower limb	Non-dominant lower limb
Mean	1.07	1.08
Variance	0.01	0.01
Observations	30	30
Df	29	29
F	1.03	
p ($F \leq f$) (1)	0.46	
F critical 1-tail	1.86	

Table 5. Two-sample *t*-test: equal variances

Outcome	Dominant lower limb	Non-dominant lower limb
Mean	1.07	1.08
Variance	0.01	0.01
Observations	30	30
Df	58	
t Stat	–0.15	
p ($T \leq t$) 1-tail	0.43	
t critical 1-tail	1.67	
p (I$T \leq t$) 2-tail	0.87	
t critical	2.00	

dominant limb in terms of knee stability. There was no significant difference between the pairs.

Discussion

One of the most examined and discussed topics in sports medicine is that of injuries. The goal of every athlete and athletic club is to eliminate the potential risk of injury and integrate into sports activities as soon as possible if an injury occurs. Prevention plays an important role in all sports [17]. As the specific load of the human body in terms of unilateral loading starts at a young age, it can lead to muscle imbalances, which are reflected in the form of insufficient muscle strength, poorer mobility in the joints, as well as other problems that constitute a potential risk of injury. A correct diagnosis can detect a unilateral load and thus allow implementing specific sports rehabilitation or training.

Our study focused on the physiotherapeutic diagnosis of lower limb dynamic stability by using YBT. The advantage of YBT is that the given movement performed during the test is similar to the movement performed by the players during ice skating.

The prevalence of knee injuries in our study was 30–70%, which represents 21 injured and 9 uninjured players. YBT is one of the generally accepted functional diagnostic methods [18]. Although YBT has shown excellent reliability in retesting, it is not known whether or not YBT will change after performing in the competitive season. Hoch et al. [15] examined and measured the effectiveness of YBT during one season. The group consisted of 20 female National Collegiate Athletic Association Division I hockey players (age: 19.55 ± 1.30 years; height: 165.10 ± 5.27 cm; weight: 62.62 ± 4.64 kg). Incorporated were those women hockey players who were unharmed throughout the study and participated in all sports activities. YBT was performed before and after the season, which lasted for 3 months. The results were compared before and after the season. Four players suffered from lower limb injuries during the season and were excluded from the analysis. There were no significant differences between the directions ($p < 0.01$), as well as no significant differences in lower limb symmetry between the preseason and postseason tests ($p \geq 0.52$).

Bhat and Moiz [19] compared the dynamic stability of the knee joint among college football and hockey players. The group consisted of 15 soccer players and 15 hockey players, with a mean age of 21 years (18–25). The subjects were not allowed to participate in other sports activities for at least 6 months, except football and hockey. The results indicated that there was no significant difference between the 2 groups in any of the test directions. Normalized reached distance was significantly higher in hockey players. We examined whether the dominant lower limb would be more stable than the non-dominant one by YBT. The relationship was without significant difference, which implies that the players had sufficient dynamic stability of the knee joints of both lower extremities.

We wanted to find out whether or not the players reported that the dominant lower limb had been more often injured. It should be stated that the dominant lower limb was revealed to have been more frequently injured. The most frequently injured structures were the ligaments (44% of cases), menisci, with injuries of various levels (16% of cases), patellar tendon (15% of cases); in 25% of cases, combinations of several injuries were present. One should note that 81% of players stated that physical contact had been the main cause of the injury, whereas the remaining 19% reported non-contact injuries. In a non-contact injury, neuromuscular control may be a more important cause.

Jonsson et al. [20] analysed injuries of elite ice hockey players in Sweden. They collected data obtained over the course of 29 hockey seasons. Overall, the study recorded 1942 injuries of 267 players. The most common injuries involved hip and groin (47.5%), spine (15.6%), and knee (12.1%). Other types of injuries were reported to a lesser extent.

In ice hockey, there is a very high risk of an injury since the players are exposed to many different factors. Taeymans et al. [21], in their retrospective study of season 2017/2018, measured the frequency, type, location, and cause of injuries, as well as the preventive measures and access to clinical care. They examined hockey players of the second-tier league in Switzerland. They evaluated 86 questionnaires; over the course of the previous 12 months, there had been 44 players injured once and 5 players injured twice. The frequency of training injuries was 0.7 per 1000 hours, and that of injuries during loading was 4.7 per 1000 hours. The 4 most frequently reported injury locations were knee joint (17.9%), foot (14.3%), head (12.5%), and shoulder (10.7%). The injuries were commonly caused by external factors. A total of 19 of the injured players reported that the convalescence period had lasted more than 4 weeks. Our study also determined the duration of convalescence: 62% of the players stated that the period from 5 to more weeks had been the longest.

The objective of a study by Tuominen et al. [22] was to analyse the prevalence, type, mechanism, and severity of injuries in international men's ice hockey tournaments. All injuries of the International Ice Hockey Federation World Championships in the course of 7 years were analysed by using a strict injury definition and standardized injury forms. During the 7 years, there were overall 844 played matches in 44 tournaments visited by 303 teams consisting of 6666 players. The study showed that there had been injuries of head and face in 210 cases, of the lower body part in 162 cases, of the upper body part in 115 cases, and of the spine in 41 cases. Knee injury was the most frequent lower-body injury (46.9%), with the rate of 2.0/1000 matches. The most frequently injured structures of the knee joint were the medial collateral ligament (56.6% of cases), meniscus (14.5%), and anterior cruciate ligament (10.5%). The 3 most usual causes of sustaining the injury were contact with another player (27.2%), contact with a hockey stick (21.1%), and contact with the puck (12.3%). Overall, 53.8% of players returned after 1 week but 14.5% of injured individuals did not return earlier than within 3 weeks.

Limitations

The main limitation of our study was its observational nature, which may be associated with several drawbacks. In the future, more studies are needed to clarify the direct connection between dynamic stability and lower limb injury.

Conclusions

The dynamic stability in the examined group of professional ice hockey players was revealed to be adequate; however, there is a need for further studies that would determine the optimal YBT values in order to prevent injuries among ice hockey players.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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