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Examination of Age-related Core Stability and Dynamic Balance in Hockey Players

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Abstract

The purpose of the study was to assess core stability and to determine age-related differences in the unilaterality of limb movements in hockey players. The sample included 152 hockey players aged 12 to 35 years. Every player performed the upper quarter and the lower quarter Y-balance tests. Performances of players showed high degree of individuality, which was expressed as the composite score. The difference greater than 4 cm in movements performed by a left or right limb indicates imbalance and higher risk of injury. Of 152 players, 27 and 26 players showed a difference higher than 4 cm for the lower quarter and the upper quarter, respectively. Of all age categories, 61% of senior players showed muscle imbalance. This may have been caused by factors present at school age because 52% of U13 players showed imbalance. We conducted statistical analysis to determine differences for each of the directions in relation to limb length. The cross-sectional data have shown non significant differences between age categories studied. For the development of ice hockey players, it is important to eliminate movement imbalance. The results have shown that the category at risk includes the U13 players, who may suffer from movement imbalance in the senior category.

Key words: injury, muscle and movement imbalance, core, Y balance test, lower quarter, upper quarter

Introduction

The trunk, which is located at the middle of the kinetic chain, is an essential region for coordination during sports performance and for preventing injuries (Imai, Kaneoka, Okubo, & Shiraki, 2014). Athletic performance depends on the creation and transfer of forces between segments of the body. For example, during the windup motion, a ground reaction force is generated between the mound and the pitcher's (the ice and hockey players) dominant lower extremity, with the force subsequently transferred through the body to the upper extremity (Brumitt, Matheson, & Meira, 2013). Hockey is a fast-paced sport with frequent changes of directions and collisions, which are determined by both trunk stability and strength. The strengthened trunk is the basis for segmental skills (skating, shooting, weaving) that require strength and coordination (Skahan, 2016). Stability provided by the muscles of the trunk is also identified as critical for whole-body

dynamic balance. To maintain whole-body stability while sustaining and/or generating external forces, athletes require both strength and endurance in these muscles (Gamble, 2007). Core stability is described in the sports medicine literature as "the product of motor control and muscular capacity of the lumbo-pelvic-hip complex". Core muscles can be divided into local and global stabilizers, which determines their ability to stabilize the spine by protecting it from the effects of load and to produce muscle force (Hibbs, Thompson, French, Wrigley, & Spears, 2008). Core stability determines the dynamic process of strengthening and maintaining the skating stance and balance. Feedback processes are regulated by the vestibular apparatus in the middle ear and muscle and joint proprioceptors through Golgi muscle spindles (Stamm, 2010). Stance stability is maintained by the trunk position while maintaining the physiological curvature of the spine (Jesenský, & Kokinda, 2017). The primary role of the local stabilizing muscles is to maintain seg-



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mental stability. Global stabilizers fulfil their stabilizing function when athletes engage in activities that require more energy and strength. The function and characteristics of these muscles is to generate torque to produce range of movement, shock absorption of load, activity is direction dependent and phasic in nature. Muscle contractions are generally concentric in nature therefore produce movement through concentric activity rather than the eccentric control displayed by the global stabilizer muscles. McLean (2006) suggested that the global mobility muscles work eccentrically to decelerate high loads and would adopt a stabilizing function when under load or when subjected to high-speed movements. Core muscles provide internal and segmental stabilization of the neutral and basic position of the spine (McGill, Andersen, & Cannon, 2015). From a skating performance perspective, core muscles play an important role in the transfer of forces between the lower body, which is in contact with the ice, and the upper body, and vice versa. Core stability determines the strengthening and maintenance of the skating stance and balance (Willardson, 2007). Bompa and Carrera (2015) consider trunk muscles the “center of movement” and an important link between the upper body and the lower body, which determines the ability of the arm muscles and lower-body muscles to generate greater force. Muscle imbalance is a state of imbalance between shortened and weakened muscles (Barcalová et al., 2017). As for ice hockey players, muscle imbalance does not affect a single muscle only because hockey performance is determined by muscle groups that work as a functional unit. Thus muscle imbalance causes poor body posture and coordination when performing the movement stereotypes, which increases susceptibility to injury.

The purpose of the study was to assess core stability and to determine age-related differences in the unilaterality of limb movements in hockey players.

Methods

Cross-sectional data were collected from 152 ice hockey players aged 12 to 35 years. Hockey players performed tests of dynamic balance, stability and mobility of particular segments of the musculoskeletal system. Using the Y Balance test protocol, we tested ice hockey players of various age categories. The test is performed on a specific Y-shaped device (Figure 1). The device consists of the center platform and distance reach indicators. By pushing the reach indicators, participants have to keep either their leg or arm at a standard height above the surface.

Testing protocol

When administering the Lower quarter Y Balance test, we focused on dynamic balance, ankle instability, and the anterior cruciate ligament injury. The tested person performed three trials with the right stance leg in the anterior direction, followed by the left leg in the same direction. This procedure was followed in other directions. The specific testing order is: right anterior, left anterior, right posteromedial, left posteromedial, right posterolateral, and left posterolateral. We recorded the maximum distance reached in each direction. The tested person was not allowed to kick the reach indicator or to use the reach indicator for support. Upper quarter Y Balance test assesses upper-body stability and mobility. During each reach component, core stability, thoracic mobility, and scapular stability are evaluated. The tested person places one of their hands on the center platform and the other hand is directed medially. The test begins in a pushup position with hands directly under the shoulders and with feet shoulder-width apart in the posterior direction. The goal of this test is to maintain a basic pushup position while on the center platform and to push the reach indicator with one hand in the designated direction. After lifting the free arm, the tested person pushes the reach indicator in direction A: medial, B: inferolateral, C: superolateral, without stopping the movement or touching the ground. After reaching in all directions, the tested person must return to the starting position without losing balance or touching the ground. The tested person has two practice trials and, subsequently, two practice trials to perform the test. A break between trials is recommended. The trial is considered valid if the tested person assumes again the starting position without losing balance or touching the ground. If there were failed attempts, a maximum of six trials were performed for any stance arm in one direction. If the tested person had more than four failed attempts, we recorded a zero for that trial. The distance reached was read to the nearest half centimeter and the maximal reach in each direction was included in the analysis. The level of dynamic balance was expressed as composite score. Length of the lower limb was determined by measuring the distance from the Anterior Superior Iliac Spine to the most distal aspect of the medial malleolus. Arm length was determined by measuring the distance from the C7 spinous process to the distal tip of the third digit of the longest finger.



Figure 1. Y Balance test kit

Data analysis

The descriptive statistical characteristics include the arithmetic mean and standard deviation for basic anthropometric parameters: body height, body weight, and limb lengths across all age categories. The levels of dynamic balance were expressed as the so-called composite score. The composite score is the sum of three reach directions divided by three times limb length, then multiplied by 100. A greater than four-centimeter right and left reach distance difference indicates imbalance and increased risk of injury. As reach distance is associated with limb length, reach distance was normalized to limb length in order to allow for comparison between players. To express reach distance as a percentage of limb length, the normalized value was calculated by using the formula: reach distance divided by limb length, multi-

plied by 100 according to Gonell, Romero and Soler (2015). We conducted statistical analysis to determine differences for each of the directions in relation to limb length. To assess significant differences between samples, we used the Kruskal-Wallis test.

This study was approved in advance by the Ethics Committee of the University of Presov. The procedures presented were in accordance with the ethical standards on human experimentation and in compliance with the Helsinki Declaration. Each participant voluntarily provided written informed consent before participating.

Results

Table 1 shows detailed characteristics of ice hockey players who participated in the study.

Table 1. Sample characteristics

	Senior (n=18)		U20 (n=15)		U18 (n=22)		U15 (n=41)		U14 (n=37)		U13 (n=19)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Age	24	4.5	18.6	0.7	16	0.8	14.6	0.4	13.7	0.4	12.6	0.3
BH (cm)	182.2	5.7	179.9	4.5	180.8	6.7	173.8	6.9	168.8	6.9	157.6	7.7
BW (kg)	88.4	7.6	80.7	4.3	74.9	11.9	66.1	9.7	58.3	7.2	48.7	11.8
LL (cm)	98.1	3.9	94.2	3.5	100	4.8	95.5	4.5	89.5	4.8	85.9	4.9
UL (cm)	95.7	8.2	91.1	3.1	93.9	3.5	90.9	4.2	85.1	4.4	79.9	5.1

Legend: BH: body height; BW: body weight; LL: lower limb; UL: upper limb.

The difference greater than 4 cm in movements performed by a left or right limb indicates imbalance and higher risk of injury. Of 152 players, 53 players showed a difference higher

than 4 cm. Figure 2 shows numbers of players who achieved a composite score higher than four for both the upper quarter and the lower quarter Y balance test.

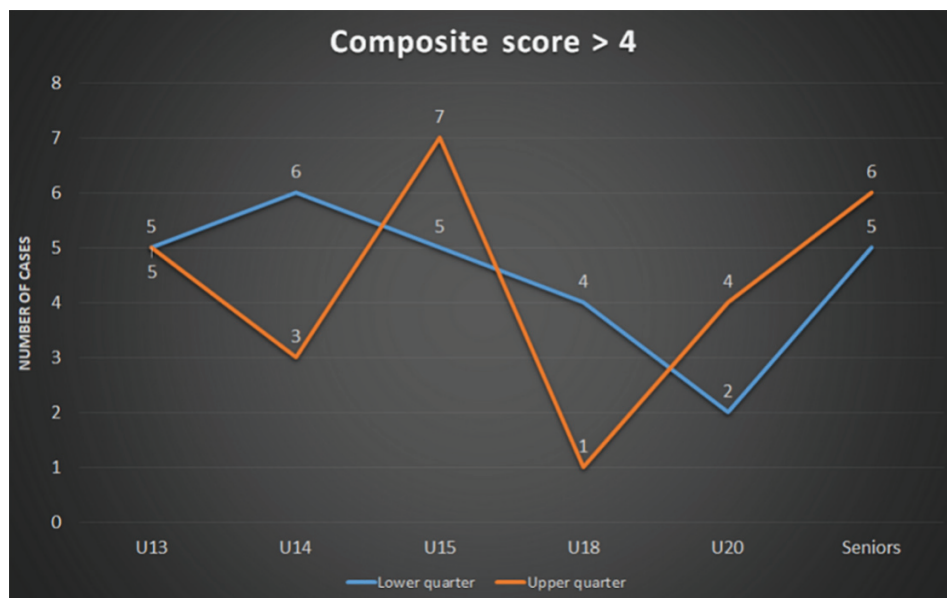


Figure 2. Composite score

Of all tested hockey players, 61% of senior players suffered from an increased risk of muscle imbalance in relation to unilateral loading. The second category in which 52% of players showed risk of injury, decreased levels of dynamic balance, and mild muscle imbalance was the U13 category. The percentages in U14 to U18 ice hockey players showed higher degree of stability that ranged from 24% to 23%. Unilaterality of

loading starts to manifest itself again in U20 hockey players of whom 40% showed muscle imbalance.

The cross-sectional data show no statistically significant relationship between distances reached and limb length. Differences in the composite scores between age categories tested were statistically insignificant as well (Figure 3). The results show that one-sided loading is sustained by U13 players already,

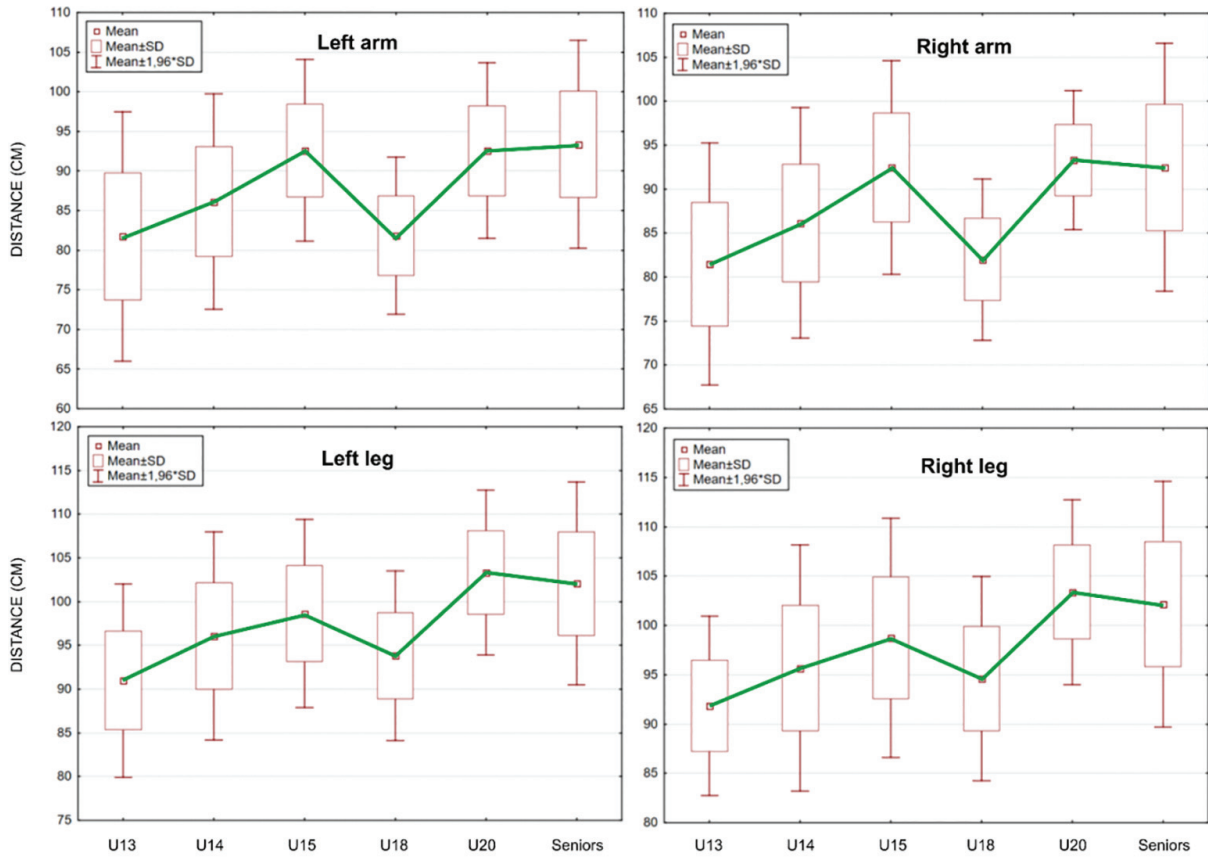
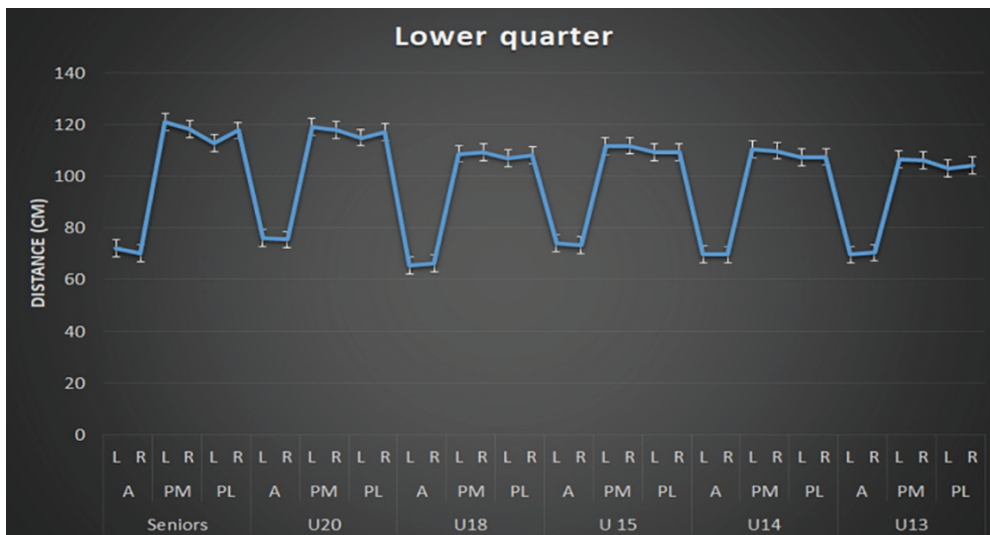


Figure 3. Comparison of examined categories – composite score

and the volume of one-sided loading increases with age. The U18 player category showed the lowest difference between the right and left limb in the distance reached, especially between the upper limbs. This may be attributed to the fact that U18 players participated twice weekly in a special training program

aimed to develop core strength. To compare the levels of dynamic balance and core stability, players' test scores were normalized to limb length according to Gonell, Romero and Soler (2015). Figures 4 and 5 show differences in distances reached for each of the directions for both the right and left limb.



Legend: L – left leg, R – right leg, A – anterior reach, PM – posteromedial reach, PL – posterolateral reach.

Figure 4. Normalized reach distance-lower quarter

Ice hockey as a sport that requires a high level of skating skills demands lower-body movements in the posteromedial

and posterolateral directions. The anterior reach appears to be problematic in terms of dynamic balance.

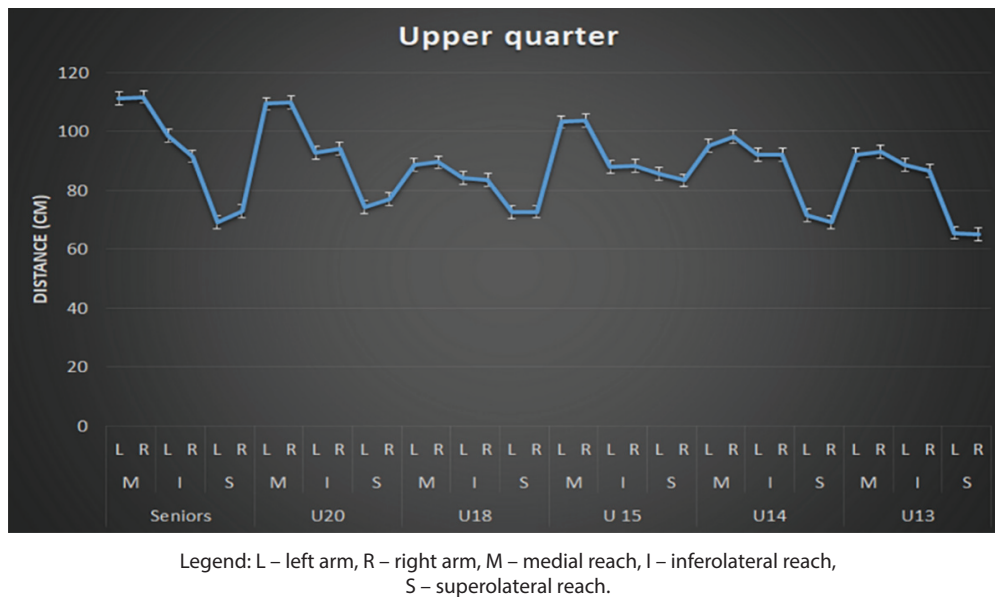


Figure 5. Normalized reach distance-upper quarter

From the viewpoint of mobility and upper-body stability, we may conclude that one-sided loading sustained by hockey players shows specifics caused by holding the stick. The superolateral reach appears to be problematic.

Discussion

Balance is one of the main elements of most physical activities and it is an important factor in the performance of sports skills (Abbasi, Tabrizi, Sarvestani, & Rahmanpourmoghaddam, 2012). Dynamic stabilization is ability to maintain equilibrium during the transition from motion to a stationary position, such as a landing movement (Myer, Ford, Brent, & Hewett, 2006). Dynamic balance is the capacity to maintain the center of mass over a fixed base of support under a movement challenge. For example, motion of other limbs and body segments (Di Stefano et al., 2011). Players use dynamic balance during tight turns and crossovers, shooting, and body contacts. Shifting the center of gravity is important when a player stands on a single leg or suddenly changes direction (Twist, 2007). The fastest natural development of dynamic balance occurs at the age between 9 and 11 years. The most critical period is the age between 11 and 13 years after which dynamic balance remains stable without targeted training stimuli (Bompa, & Carrera, 2015). Dynamic movement testing during the preparticipation examination is gaining popularity as a component of musculoskeletal screening with the goal of identifying increased injury risk (Gorman, Butler, Plisky, & Kiesel, 2012). The Lower Quarter Y Balance test (LQYBT) is a screen of dynamic balance requiring stance leg balance while the contralateral leg reaches in anterior, posteromedial and posterolateral directions (Smith, Chimera, & Warren, 2015). The upper quarter Y-balance test (UQYBT) has been proposed as a closed kinetic chain assessment of upper quarter mobility and stability using a functional testing device (Westrick, Miller, Carow, & Gerber, 2012). Motion programs and exercises aimed at musculoskeletal system aim to prevent a reduction of the functional ability not only of the spine, but also muscles to the range of mobility and eliminate pain (Bendíková, Uvinha, & Marko, 2016). Otherwise deformation caused by a high degree of sports specialization and unilaterality of load occurs. Tyler,

Nicholas, Campbell and McHugh (2001), who studied the relationship between lower body and skating, found that players with weaker adductor muscles were more likely to experience an adductor strain during the season. Furthermore, players whose adductors were markedly weaker than their abductors were more likely to experience an adductor strain. By contrast, adductor flexibility was not associated with adductor strains. As reported by Tyler et al. (2001), preseason hip strength testing of professional ice hockey players can identify players at risk of developing adductor strains. Hip adduction strength was 18% lower in players who subsequently sustained an adductor strain compared with that of uninjured players. Moreover, a player was 17 times more likely to sustain an adductor strain if his adductor strength was less than 80% of his abductor strength. Of methods applied to assess muscle imbalance, the Functional Movement Screen is considered reliable. Functional Movement Screen is a reliable test for young elite hockey players. This study demonstrates that the FMS is a reliable test for young elite hockey players. Physiotherapists as well as other health professionals involved with young hockey players could integrate the FMS into their clinical exam in order to suggest interventions that focus on movement pattern deficits observed during the sub-tests. It appears that pain can be an issue for the clearing exam scoring. Pain can also have an effect on whether or not a score of 0 should be attributed to the performance of the other sub-tests. This impact could be lessened by adding standardized questions which require clear yes or no answers. Interesting research avenues remain to be explored. The predictive validity of the FMS test within this population could be assessed. Moreover, further studies could investigate psychometric properties of the FMS in other populations vulnerable to overuse injuries due to a movement pattern deficit like workers performing physically demanding duties. This could promote the FMS test as an evaluation tool for physical therapy practice among various populations.

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Conflict of Interest

The authors declare that there are no conflict of interest.

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