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The effect of core training on dynamic balance and strength endurance in junior field hockey players

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Abstract

Introduction: The objective of this study is to find the effectiveness of core muscle strength training on dynamic balance and muscle endurance among junior field hockey players. Material and Methods: The study was conducted with 30 regular junior hockey players (15 in the control group and another 15 in the experimental group). The modified Star Excursion Balance Test (mSEBT) and Biering-Sorensen muscle endurance tests are used to assess dynamic balance and endurance. In the control group, the participants continued their formal training without undergoing any intervention. At the same time, the players in the experimental group performed the core muscle strength training daily for 45 minutes per session for eight weeks. Results: The result showed a statistically significant difference seen on both mSEBT and Biering Sorensen Endurance test between the control and experimental groups. The mSEBT had a higher mean score in the experimental group, right limb (97.6%) and left limb (97.9%), than the control group right limb (91.7%) and left limb (92.6%). The mean endurance time in the experimental group had a higher endurance time of (135.4 sec) than the control group (176.2 sec). Conclusion: This study showed that core muscle strengthening exercises enhance the dynamic balance and endurance in junior field hockey players.

Keywords

field hockey, dynamic balance, muscle endurance, Star Excursion Balance Test

Cover Page Footnote

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Article

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Keywords: field hockey, dynamic balance, muscle endurance, Star Excursion Balance Test.

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1. Introduction

Hockey is one of the famous and successful sports which is played by men and women at every level ranging from junior to professional players [1]. It is a dynamic and competitive sport which requires different movement patterns which predispose to various types of musculoskeletal injuries [2, 3]. The players continuously require walking, running, stepping, and jumping movements; this leads to a challenge for their dynamic balance and endurance [4]. Mostly the junior players considerably have a higher risk of incidence of overuse complaints, and so junior players are repeatedly exposed to a greater risk of injuries than adults [5]. Muscular strength, endurance, and dynamic balance are the physical skills required in most of the game. Any disturbance in these skills while moving will further make a player prone to several injuries and decreases output during the game [6]. Recently, it has been recognized that in different movement patterns, muscular imbalance, poor neuromuscular control, and instability in the core muscles are the risk factors for athletic injuries [7, 8].

Field hockey demands good dynamic balance, which is an essential component of injury prevention, rehabilitation, and which significantly affects athletic performance [9,10]. Poor balance increases the risk of injury in many sports [11]. Hockey is a game in which the player is required to move or run while performing the skill, and also they need to seek a balance position. This well-balanced position is essential while playing an attack role, moving quickly in all directions, passing or receiving the ball from any direction [1].

The ability to maintain a particular position or to perform as many repetitions as possible is called core endurance [12]. This endurance plays a key role in maintaining balance, coordination, and sport-specific tasks, and also it ensures stability of spine for the production of force and prevention in injury. It is the most essential component in core muscle training [13], which helps to maintain an effective trunk position. If there is any weakness or poor endurance of these muscles, it may induce muscular imbalance on the lumbar spine structures, which results in low back pain [14]. Any impairment in the trunk muscle will lead to a decreased strength or endurance, which influences the players' balance and mobility.

Adequate endurance of these core muscles plays a crucial role in maintaining coordination, balance and sports-specific tasks. Core muscle stability and balance are necessary for all sports activities, and they are important for neuromuscular control and the capacity of the lumbopelvic-hip complex [15, 16]. These core muscle stability and balance training programs were universally accepted as an essential part of many sports conditioning programs. The stabilization of abdominal, par spinal, and gluteus muscles leads to better stability and control [17]. The stability training increases the core muscle strength, motor control and endurance. Core strength training helps to improve muscular coordination and dynamic balance among upper and lower extremities [18], reduces strength imbalances, and prevents injuries in lower limb and knee joint [15, 19]. Any changes in the core strength will lead to alternations in the transferring forces and decrease the performance, and this will increase the risk of injury mainly in the lower extremities [20].

Core muscle strength training has a possibility in improving the strength as it is related to the health and skill components of physical fitness among adults. Most studies and interventions focus on the lower limb in the posture and balance context, whereas core strength and endurance deficits have not been apparent. So, the core muscle exercises are not given importance in a training program design. These exercises address the strength of the lumbopelvic-hip complex muscles to work in an efficient coordinated manner that helps to improve balance and stability. The majority of sports depends on the strength of stable core muscles [21, 22]. Therefore, this study has been designed to investigate the effectiveness of core muscle strength training on dynamic balance and muscle endurance among junior field hockey players. We hypothesized that an eight-week core muscle strength training program will improve the dynamic balance and muscle endurance in comparison with a standard muscle strength training program among junior field hockey players.

2. Materials and Methods

The experimental study was conducted among regular junior hockey players who were all available from November 2018 to January 2019 in Sardar Vallabhai Patel International Hockey Stadium located in Raipur, Chhattisgarh, India.

2.1. Participants Eligibility

Inclusion: The study group includes both genders of junior hockey players aged between 12 to 17 years, with an average of 145.8 ± 9.08 cm height and 37.1 ± 9.04 kilograms weight. In addition, the participants were expected to have at least one year of experience in field hockey.

Exclusion: This study excluded the participants who had any acute inflammatory conditions of the back, spinal fractures, and systemic conditions affecting the muscle performance, spinal instability, or any musculoskeletal, cardiac, and presents of neurological deficits: history of seizure, headache, spinal cord injury.

Selection of subjects: For the present study, 30 junior hockey players were randomly selected. The players were divided into two groups as the experimental group and the control group. Each group consisted of 15 players.

A semi-structured questionnaire: A semi-structured questionnaire was used to record basic demographic details which included the details of age, gender, height, weight, duration of the training per day.

2.2. Measurements

2.2.1. The Modified Star Excursion Balance test (mSEBT)

The mSEBT is used to measure the dynamic balance. It is a screening tool that measures the reach distance in anterior (A), posterior medial (PM), and posterior lateral (PL) in three different directions. Before performing the test, participants were instructed to remove their shoes and stand at the center of a grid, where three lines met each other in the form of Y. The participants were asked to maintain stable balance on one leg and with another leg to reach the maximal distance as far as possible in three directions. They were instructed to make a light touch with their distal part of the big toe on the maximal reach distance on the line, and then the leg returned to the center. Three reaches in each direction were recorded, and a rest of 15 seconds were given for participants between each reach. The best of the three reaches from each leg from the three directions was considered for the final analysis [23]. The limb length was measured using an inch tape from the anterior superior iliac spine to the most distal portion of the medial malleolus [24, 25].

2.2.2. Biering-Sorensen endurance test

The isometric endurance of the hip and back extensor muscles were assessed using the Biering-Sorensen endurance test. The test had been described as measuring how many seconds the participants could keep their unsupported upper portion of the body horizontal while they were placed in the prone position with their buttocks and legs fixed to the couch by three wide canvas straps and their arms folded across the chest. The participants were positioned prone lying at the edge of the table, with the pelvis and both legs manually supported by the physiotherapist. The upper half of the body was initially supported on the stool until they were asked to cross their arm and assume a horizontal position, which is to be actively maintained by participants for as long as possible. The time for which participants could hold the horizontal position (i.e., the time between the assumption of the horizontal position up to the moment when they lost the horizontal position) was recorded with a stopwatch [26, 27].

2.3. Exercise Protocol

The participants of both groups continued their standard training sessions for eight weeks during the intervention. The experimental group performed the core muscle strengthening exercises daily for 45 minutes per session, and the control group continued their normal training session without undergoing any intervention [28]. The experimental group performed each exercise as mentioned in Table 1.

Table 1. Core muscles strengthening exercises performed by the experimental group (Hoppes CW)28

Exercises and Description	Repetitions
Abdominal Drawing in-Crunch The participants lie supine with knees bent and with arms crossed over chest and the feet flat on the floor. They have been instructed to pull the lower abdominal muscles up and into spine and slowly lift the shoulders from ground and curl the stomach. They are asked to hold for 10 seconds and then slowly curl trunk back down.	Perform 6 repetitions in 1 minute
Horizontal side support: Right side/Left side The participants, lie on right side with one leg top of the other leg. The right side elbow is kept directly under the shoulder and supported by the upper body weight. The participants were instructed to pull the lower abdominal muscles up and into the spine and lift the hips up and down from the ground until the body is in straight line from feet to the shoulders. The participants relax back to the floor and it is repeated until the total set is complete to the right side. After completion turn back to the left side and done same as done it the right side.	For each side Group in 5 counts and down in 5 counts. Perform 6 repetitions in 1 minute
Plank Exercises: Prone The participants lie prone on the floor with legs straight and feet together. Their upper body is supported with elbow and forearms. In this position, they pull their lower abdominal muscles up and into spine. By keeping the whole trunk straight, the participants lift up the entire body off the ground and the body weight is supported the elbows and forearm, with elbows right under the shoulders. The participants pull the shoulders down and back without slump, and hold this position as long as they can control.	Hold for 15 seconds in "up" position then slowly return to start. Perform 4 repetitions, 15 seconds each.
Bridging Exercises: supine The participants lie in supine position with their knees bent to 90 degree and feet flat on the floor. In this position, they pulled their lower abdominal muscles up and into spine, and then the participants lift off the hip towards ceiling as high as they can do.	Perform 4 repetitions in 1 minute.
Quadruped exercises: Arm & leg raise alternate The participants are on the ground with both their hands and knees. In this position, the participants pull lower abdominal muscles up and into spine. Simultaneously, they stretch out the right and the left leg for 3-second count, hold for 5 seconds (do not arch back), then slowly return to the start position. With each repetition, alternate opposite arm and leg.	Perform 6 repetitions in 1 minute
Hamstring Raise Exercises The participants are on the ground with their both hands and knees and with their back flat and arms/ thighs perpendicular to the ground. The slowly raise one leg behind until it is horizontal and hold this position for as long as they can and return back to the starting position, and then repeated to the other leg.	Perform 6 repetitions in 1 minute

2.4. Procedure

All the study participants and their parents were explained the study procedure and informed consent was obtained before assignment to groups. A simple random sampling method was used to divide the participants into the experimental and control groups. This study was conducted in pre and post-test experimental design, and all the participants were tested for dynamic balance and core muscle endurance through the Modified Star excursion balance test and Biering Sorensen endurance test.

Participants in the experimental group underwent the core muscle strengthening exercises of hip extensors, lower back, and abdominal muscles, and their usual warm-ups and stretching. The control group participants underwent regular activities of warm-up and stretching programs. The training program was demonstrated for 45 minutes daily in the evening session for two weeks. The participants were asked to continue practicing for six weeks under the supervision of the physiotherapist. After the completion of a total of eight weeks of the initial intervention, the post-test was conducted.

2.5. Data Analysis

By using the descriptive statistics of mean, standard deviation, and percentile, the data were summarized. Wilcoxon signed-rank test was used to measure the difference in mSEBT reach distance and endurance time for the pre and post-test of both the control and experimental groups. Mann-Whitney U tests were used to measure the difference in mSEBT reach distance and endurance time between the post-test of the control and experimental groups. The probability of a p-value less than 0.05 was considered significant. All these statistical analyses were performed through SPSS 17.0 (IBM SPSS, 2007, Chicago, IL).

3. Results

The demographic and anthropometric data are shown in Table 2. Both the control and experimental groups were similar in age, height, weight, body mass index, and lower limb length.

Table 2. Participants' demographic and anthropometric information.

Variables	Control Group (n=15)		Experimental Group (n=15)		*p*-value
	Mean ± SD (95% CI)		Mean ± SD (95% CI)		
Age (years)	14.5 ± 2.3	(13.3-15.8)	14.2 ± 2.2	(13.0-15.4)	0.68
Height (cm)	146.7 ± 10.7	(140.8-152.7)	144.9 ± 7.4	(140.8-149.0)	0.58
Weight (kg)	38.5 ± 9.8	(33.1-44.0)	35.7 ± 8.2	(31.1-40.2)	0.39
Body Mass Index	17.7 ± 3.1	(16.0-19.4)	16.9 ± 2.8	(15.3-18.4)	0.44
Lower limb length					
Right side (cm)	87.1 ± 4.9	(84.4-89.9)	87.9 ± 6.4	(84.4-91.5)	0.70
Left side (cm)	87.1 ± 4.9	(84.4-89.9)	87.9 ± 6.4	(84.4-91.5)	0.70

The mean limb length reach distances, and composite reach scores for the control group and experimental group are shown in Table 3 and Table 4. There was a significant difference in anterior, poster medial, poster lateral, and composite (anterior + posteromedial + posterolateral) reach distances scores between before and after training ($p = 0.05$) among the control group (as shown in Table 3) and the experimental group (as shown in Table 4).

Table 3. Performance of the modified SEBT for the control group (n = 15).

mSEBT	Mean	±SD	Minimum	Percentiles 25th	Percentiles median	Percentiles 75th	Maximum	*p*-value
1. Anterior direction, % limb length								
Right limb								
Pre test	87.6	±2.6	84.5	85.7	87.5	89.2	93.5	0.00**
Post test	88.6	±2.7	84.8	86.2	88.2	89.7	94.8	
Left limb								
Pre test	87.0	±4.9	79.4	82.6	87.1	89.4	98.7	0.01*
Post test	88.3	±5.2	81.9	84.5	88.0	90.6	101.3	
2. Poster medial direction, % limb length								
Right limb								
Pre test	93.6	±2.9	89.7	92.0	93.2	94.3	101.3	0.01*
Post test	94.2	±2.8	90.2	92.2	94.1	95.3	101.3	
Left limb								
Pre test	94.6	±5.5	86.6	90.9	94.0	96.6	109.1	0.03*
Post test	95.4	±5.2	86.7	91.3	95.2	98.8	109.1	
3. Poster lateral direction, % limb length								
Right limb								
Pre test	91.7	±3.6	86.6	88.9	90.9	94.0	98.7	0.02*
Post test	92.3	±3.6	87.2	90.0	90.9	94.0	100.0	
Left limb								
Pre test	92.8	±4.7	84.5	89.4	93.1	94.3	105.2	0.05*
Post test	94.1	±4.5	87.0	90.4	94.0	97.6	103.9	
4. Composite score, % limb length								
Right limb								
Pre test	91.0	±2.9	86.9	89.3	91.2	91.9	97.8	0.00**
Post test	91.7	±2.9	88.0	89.8	91.3	92.8	98.7	
Left limb								
Pre test	91.4	±4.9	83.5	88.3	90.9	93.6	104.3	0.00**
Post test	92.6	±4.7	86.3	88.7	91.3	96.1	104.8	

Table 4. Performance of the modified SEBT for the experimental group (n = 15).

mSEBT	Mean	±SD	Mini-mum	Percentiles			Maxi-mum	*p*-value
				25th	median	75th		
1. Anterior direction, % limb length								
Right limb								
Pre test	87.7	±3.6	81.0	85.2	87.8	91.3	92.6	0.00**
Post test	93.8	±3.8	86.0	91.4	94.0	96.6	100.0	
Left limb								
Pre test	88.0	±7.6	76.2	83.0	87.8	91.4	105.0	0.00**
Post test	95.5	±7.5	82.2	92.0	94.4	98.8	110.0	
2. Poster medial direction, % limb length								
Right limb								
Pre test	93.6	±3.3	87.1	91.4	94.2	96.3	98.8	0.00**
Post test	100.0	±3.5	93.1	97.8	100.0	103.7	104.9	
Left limb								
Pre test	94.1	±6.8	84.0	87.8	93.8	97.6	107.5	0.00**
Post test	99.2	±7.5	89.0	92.5	100.0	102.5	115.0	
3. Poster lateral direction, % limb length								
Right limb								
Pre test	92.0	±3.9	85.0	89.8	92.0	95.0	97.6	0.00**
Post test	99.0	±4.1	92.0	96.6	98.9	102.5	106.2	
Left limb								
Pre test	93.1	±8.0	79.2	87.1	94.3	96.3	108.8	0.00**
Post test	99.0	±8.9	83.2	92.2	97.7	104.9	116.3	
4. Composite score, % limb length								
Right limb								
Pre test	125.2	±8.8	110.0	119.0	127.0	133.0	138.0	0.00**
Post test	176.2	±9.2	162.0	168.0	174.0	185.0	189.0	
Left limb								
Pre test	91.1	±3.5	84.8	88.6	91.5	94.2	96.3	0.00**
Post test	97.6	±3.7	90.7	95.1	98.1	100.8	102.9	

The hip-trunk extension mean endurance time in seconds for the control group and the experimental group is shown in Table 5. There was a significant difference in before and after training among the control group and the experimental group.

Table 5. Performance of the hip and trunk extension endurance time (sec) measured using the Biering-Sorensen test for the participants (n = 30).

Endurance time (sec)	Mean	SD	Mini-mum	Percentiles			Maxi-mum	*p*-value
				25th	median	75th		
Control group								
Pre test	127.9	7.2	115	124	128	135	141	0.00**
Post test	135.4	8.4	123	130	135	140	150	
Experimental group								
Pre test	125.2	8.8	110	119	127	133	138	0.00**
Post test	176.2	9.2	162	168	174	185	189	

3.1. A significant difference in mSEBT and Biering-Sorensen endurance test after the intervention

mSEBT: The results show a statistically significant difference seen on the mSEBT composite score, % limb length between the control and experimental groups after the intervention (as shown in Table 6). The experimental group (97.6%) had a higher mean score in the right limb than the control group (91.7%). The experimental group (97.9%) had a higher mean score in the left limb than the control group (92.6%).

Biering-Sorensen endurance test: A statistically significant difference can be seen in the Biering-Sorensen endurance test between the control and experimental groups after the intervention (as shown in Table 6). In the hip-trunk extension mean endurance time, the experimental group (135.4 sec) had a higher mean endurance time than the control group (176.2 sec).

Table 6. Performance of the mSEBT and the Biering-Sorensen endurance test after the intervention between the control and experimental group.

Variables	Control Group (n=15)		Experimental Group (n=15)		*p*-value
	Mean ± SD		Mean ± SD		
mSEBT, Composite score, % limb length					
Right limb	91.7	±2.91	97.6	±3.70	0.00**
Left limb	92.6	±4.74	97.9	±7.81	0.04*
Biering-Sorensen test					
Endurance time (sec)	135.4	±8.39	176.2	±9.20	0.00**

4. Discussion

There are many studies about muscle strength and dynamic balance in different geographical areas, but there is limited information among junior hockey players, probably in state like Chhattisgarh in India. The study aimed to find the effect of core muscle strength training on dynamic balance and muscle endurance among junior field hockey players. For better balance and performance, hockey players must have good strength, range of motion in joints, proprioception, neuromuscular control, and sensory-motor function.

In sports, while performing different movement patterns like walking, running, stepping and jumping the athletes were continuously exposed to risk situations where their balance is dynamically challenged. A hockey player is normally moving or running at the same time while performing a skill and they have to seek point of balance in relation to the ball. A well balanced position is necessary in every game, while playing different roles (attack, pass or shoot the ball) in relation to the ball in any direction [12].

Any fatigue in the core muscle will lead to decreasing the dynamic stability and balance control [29]. Hence, core strength is considered a key component in ensuring good performance in athletes. It helps in improving the dynamic balance and muscle coordination among the lower and upper extremities [18]. The star excursion balance test (SEBT) is more dependent on neuromuscular characteristics, such as strength, flexibility and proprioception [30]. The stance leg needs ankle dorsiflexion and flexion at the knee and hip joints. Also, it requires neuromuscular control, proprioception as well as adequate strength to perform these reaching tasks. A study conducted among soccer player found that athletes who are prone to ankle injuries have poor or decreased balance [31]. This study compared the dynamic balance among junior field jockey players using the star excursion balance test (mSEBT). The result found that both the control and experimental groups significantly improved dynamic balance at the end of the eight-week training programs. Also, it showed there was a significant improvement of the experimental group (Rt limb-97.6%, Lt Limb-97.9%) than the control group (Rt limb-91.7%, Lt Limb-92.6%) at the end of the eight weeks in dynamic balance on mSEBT composite score.

Core muscle strengthening provides stability to the lower limb movements and allows it in a smooth and stable movement [17, 32]. To improve the athletic performance, most of the core muscle training was designed in way to improve the essential components of trunk strength and muscle endurance. Core muscle strength is required in all sports; the muscle endurance plays a significant role in maintaining the spinal stability during prolonged sports activity and also it protects from injury [21,33-34]. Thus sufficient endurance of core muscles has an important role in maintaining the coordination, balance and sports-specific tasks.

To achieve balanced movements during upper and lower activity, core stabilization is essential, and it is emphasized that it is a support point for all distal segment movements [35]. In addition, every balance training problem should include core stabilization exercises. They improve body awareness and act as a muscular corset, when the core area is limped or absent with limb movement. The increased core strength and endurance play an important role in improving the efficiency [36].

A study conducted among high school track and field athletes found that after six weeks there was a significant increase in the observed core endurance tests [37]. The experimental group, in contrast with the control group, showed a significant increase in the isometric endurance of hip and back extensor muscles (Biering-Sorensen test) and dynamic balance in the reach distance among anterior, posterior medial, and posterior-lateral directions (mSEBT).

In preventing and treating the LBP, the endurance capabilities are more important than the strength. Improved endurance acts as a safeguard mechanism for preventing low back pain. Core stability training helps for significant improvement in the lower trunk musculature endurance [12]. Improved endurance performance could be considered a reduced risk of developing low back pain. The study results showed a significant effect of the experimental group (176.2 sec) than the control group (135.4 sec) in hip and trunk extension endurance time on the modified Biering-Sorensen test.

Muscular endurance is very essential for the level of physical fitness and the normal functioning of the human body. Hence, any reduction in the endurance will lead to abnormal movement or displacement in different parts of the body. According to a theory, any decrease in trunk muscle endurance will lead to muscle fatigue, and it will increase the pressure on soft tissues and other inactive structures of the lumbar spine. Thus, the core strength training is important in preventing and rehabilitating spinal problems and improving performance, considering their effectiveness in enhancing trunk muscle endurance [38].

In a game, a junior hockey player (average 25 times) gets more chance of getting injured (96.1 per 1000 player-game hours) than in practice (3.9 per 1000 player-practice hours) [39]. Hence, trunk-hip endurance and dynamic balance would help prevent injury among young athletes, especially junior field hockey players. A stable core decreases the chance of injury and improves the performance to keep the balance through specific movements. A weak core muscle will lead to bad posture, low back pain, and ultimately injury [40].

The eight-week core strengthening exercise program can increase the core muscle activation, and it will also increase core muscle endurance [28]. It has been confirmed in many studies that core stability and endurance are essential components to maximizing dynamic balance and athletic movements function with upper or lower limbs. This study results showed that eight weeks of core stability training for the experimental group increases the core muscle endurance and dynamic balance more than in the control group. The limitation in our study is that the sample size is relatively small and the study included mostly male junior hockey players.

5. Conclusions

In conclusion, this study showed that core muscle strengthening exercises enhance the dynamic balance and muscle endurance in junior field hockey players. Therefore, core muscle strengthening training can be incorporated into the routine training programs to improve junior field hockey players' dynamic balance and muscle endurance, which may eventually improve the performance outcome.

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