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Relationship between Balance and Isokinetic Strength of Ankle Joint by Playing Position of Elite Female Field Hockey Players

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Abstract

Playing field hockey, similar to soccer, has an impact on various physical attributes, including muscle strength, which is a major factor in balance. The objective of this study was to analyze the correlation of static (SI) and dynamic (TCT) balance and isokinetic strength (PT/BW and WK/BW) of the ankle joint by playing position for elite female field hockey players. The static and dynamic balance of forwards was closely related to isokinetic strength of evertors and dorsi flexors concentrically and eccentrically, and the dynamic balance of midfielders was closely related to isokinetic strength of dorsi flexors concentrically and eccentrically. Our results indicate that the balance of hockey players correlates with isokinetic strengths of the ankle and the type of contraction, depending on the players' position. Therefore, a training protocol for improving balance ability to improve athletic performance and prevent ankle joint injuries should include isokinetic strengthening exercises for the ankle joint, based on the playing position in the field.

Keywords: Balance, Field Hockey Player, Isokinetic Strength

1. Introduction

Field hockey has various physiological and technical characteristics in common to those of soccer; it is a team sport with multiple high-intensity activities with a multidirectional nature[1]. In particular, the ability to perform redirection rapidly while maintaining balance without loss of speed is a critical physical component necessary for successful performance in field hockey[1]. Understanding these physiological attributes in team sports, especially in elite athletes, is necessary to develop a sport-specific training protocol [2].

Balance, which is an important attribute in field hockey players, can be defined as the static ability to maintain a base of support with minimal movement and as the dynamic ability to perform a task while maintaining a stable position[1–3]. Poor balance ability has been demonstrated to be associated with an increased risk of ligament injuries[4]. Further, a deficit in the static and dynamic balances can affect the competition outcome[5]. Therefore, balance ability is a very important factor in many sports.

In players of team sports such as soccer and field hockey, various factors such as the position played on the team and the style of playing have an impact on the musculoskeletal profile of players[6]. Playing field hockey, similar to soccer, also has an impact on various physical attributes, including muscle strength, which is a major factor in balance. For field hockey, various studies have examined the qualities that separate performers of different skill levels; however, little is known about the positional specificity of physical attributes. Thus, the objective of this study was to analyze the correlation of between balance and isokinetic strength of the ankle joint based on playing position for elite female field hockey players.

2. Methods

2.1 Subjects

The subjects of this study comprised 20 elite female hockey players (defenders (DF) = 7, forwards (FW) = 5, and mid

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fielders (MF) = 6) registered in the Korean national team. Subjects who had undergone ankle joint surgery within 1 year or experienced pain within 3 months before enrollment were excluded. All subjects signed a written informed consent form to participate in the study.

2.2 Measurement for Balance

Static and dynamic balance was measured as the Stability Index (SI) and Test Complete Time (TCT), respectively, by using the Biodex Balance System (Biodex Medical Systems Inc., Shirley, USA). SI was measured by completing three stages for 20s with the dominant single leg standing on a moving platform, and TCT was measured by in eight stages by completing 9 missions with the dominant single leg on a moving platform[7]. Both methods were used without prior practice by the players. A high score indicated lower balance ability.

2.3 Measurement for Isokinetic Ankle Concentric and Eccentric Strength

For identifying the isokinetic strength of the ankle joint, peak torque/body weight (PT/BW) and work/body weight (WK/BW) of the ankle concentric and eccentric evertors at 30°/s, 60°/s, 90°/s and 120°/s, and PT/BW and WK/BW of ankle concentric and eccentric dorsi flexors at 30°/s, 60°/s, 90°/s and 120°/s was measured by using the Biodex System III (Biodex Medical Systems Inc., Shirley, USA). For isokinetic ankle strength measurement of evertors concentrically and eccentrically, at a neutral position (0°) of the subtalar joint and 10° to 15° of plantar flexion in the talocrural joint, a range of 40° from eversion of 15° to inversion of 25° was measured[8,9]. For isokinetic ankle strength measurement of the dorsi flexors concentrically and eccentrically, at knee flexion of 10° and neutral position of talocrural joint, a range of 40° from 20° of dorsiflexion to 20° of plantar flexion was measured[10,11]. All values were completed with five repetitive measurements after three prior practice motions. Higher scores indicated higher muscle strength.

2.4 Data Analysis

All data were expressed as the mean and standard deviation. To identify the relationship between static and dynamic balance and isokinetic strength of the ankle joint, correlation analysis was performed using SPSS for Windows ver. 19.0 (IBM, Armonk, NY, USA). All levels of statistical significance were set at $\alpha = 0.05$.

3. Results and Discussion

3.1 Mean and Standard Deviation Values for Balance and Isokinetic Strength

Tables 1-4 show the mean and standard deviation for all the measured data. SI was higher in FW than DF and MF, and TCT was higher in DF than MF and FW. That means that static balance ability in FW was lower than DF and MF, and dynamic balance ability in DF was lower than MF and FW Table 1. Isokinetic strength (PT/BW) of the ankle concentric evertors in DF and FW at 30°/s was the highest, and that in MF at 90°/s was the highest, and Isokinetic strength (PT/BW) of the ankle eccentric evertors in DF and FW at 60°/s was the highest, and that in MF at 90°/s was the highest Table 1. Isokinetic strength (WK/BW) of the ankle concentric and eccentric evertors in DF, FW, and MF at 30°/s was the highest Table 2. Isokinetic strength (PT/BW) of the ankle concentric dorsi flexors in DF, FW, and MF at 30°/s was the highest, and Isokinetic strength (PT/BW) of the ankle eccentric dorsi flexors in DF at 60°/s was the highest, and that in FW and MF at 120 °/s was the highest Table 3. Isokinetic strength (WK/BW) of the ankle concentric and eccentric dorsi flexors in DF, FW, and MF at 30°/s were the highest Table 4.

While several studies have examined physical and physiological characteristics as affected by playing positions in soccer, few such studies are available for hockey. For soccer, Mclntyre and Hall[12] reported that midfielders did have significantly larger body mass than backs (the same position as defenders), with greater maximal oxygen consumption and vertical jumping ability than backs and forwards among Gaelic footballers; further, midfielders also had greater absolute handgrip strength. According to Gabbet's study[13], female hockey players in Australia covered 6.6 km over the course of the match, and midfielders spent more time and covered greater distances in high-intensity running than forwards and defenders. Further, the number of high-velocity and high-acceleration efforts over the course of a match by midfielders was greater than that by other players[13].

3.2 The Correlation of Balance and Isokinetic Strength for Ankle Concentric and Eccentric Evertors

In forwards, SI was significantly related to isokinetic strength (PT/BW) of the ankle eccentric evertors at 120°/s ($r = -.925$, $p = .024$), and TCT was significantly related to isokinetic strength (PT/BW) of the ankle

Table 1. Mean and Standard Deviation (SD) values for balance and isokinetic strength (PT/BW) of the ankle concentric and eccentric evertors by playing position

		SI (index)	TCT (s)	Concentric evertors ($N \cdot Kg^{-1}$)				Eccentric evertors ($N \cdot Kg^{-1}$)			
				at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	Mean	2.11	160.29	44.26	44.03	41.80	38.20	48.87	53.37	52.24	52.54
	SD	0.41	42.55	9.73	11.45	10.40	10.52	9.70	11.83	11.12	7.75
FW	Mean	2.34	151.80	43.48	38.32	33.72	34.22	43.88	44.32	42.12	38.60
	SD	0.64	42.11	10.27	9.06	7.90	11.47	4.11	6.67	6.82	16.38
MF	Mean	2.20	134.33	41.45	39.90	45.72	38.30	45.32	50.85	55.00	48.27
	SD	0.82	16.70	10.29	7.42	18.33	10.07	12.57	16.66	24.29	23.81

Table 2. Mean and Standard Deviation (SD) values for isokinetic strength (WK/BW) of the ankle concentric and eccentric evertors by playing position

		Concentric evertors ($J \cdot Kg^{-1}$)				Eccentric evertors ($J \cdot Kg^{-1}$)			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	Mean	17.54	16.66	14.61	12.93	19.40	18.40	15.60	11.56
	SD	4.19	4.09	3.10	3.43	3.10	4.41	3.30	3.04
FW	Mean	17.80	15.42	13.02	11.72	20.96	16.86	12.18	7.50
	SD	4.07	3.42	2.90	3.60	8.10	3.83	3.65	3.72
MF	Mean	17.03	15.72	16.18	12.97	19.08	13.82	15.48	10.35
	SD	4.23	3.55	6.17	3.34	5.01	5.45	8.72	8.35

Table 3. Mean and Standard Deviation (SD) values for isokinetic strength (PT/BW) of the ankle concentric and eccentric dorsi flexors by playing position

		Concentric dorsi flexors ($N \cdot Kg^{-1}$)				Eccentric dorsi flexors ($N \cdot Kg^{-1}$)			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	Mean	34.56	34.46	26.24	17.40	51.67	57.77	50.84	42.84
	SD	6.28	3.17	4.15	8.20	4.84	15.16	3.42	19.13
FW	Mean	41.30	29.08	23.50	25.28	51.40	50.64	37.44	51.90
	SD	6.97	4.61	15.71	12.24	9.33	7.58	21.09	4.28
MF	Mean	42.87	34.08	27.67	24.88	52.57	52.02	58.38	70.85
	SD	6.92	6.54	6.67	6.19	5.50	7.60	13.75	32.71

Table 4. Mean and standard deviation (SD) values for isokinetic strength (WK/BW) of the ankle concentric (CDF) and eccentric dorsi flexors (EDF) by playing

		Concentric dorsi flexors ($J \cdot Kg^{-1}$)				Eccentric dorsi flexors ($J \cdot Kg^{-1}$)			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	Mean	19.37	12.23	8.56	5.20	22.24	21.69	16.09	8.81
	SD	8.41	1.70	1.08	2.39	2.02	5.93	1.76	4.17
FW	Mean	20.70	10.20	7.32	6.64	21.34	19.18	10.62	11.60
	SD	6.31	1.88	4.43	1.74	5.89	3.47	6.12	2.67
MF	Mean	21.33	12.00	9.23	7.77	22.98	19.87	18.10	17.33
	SD	6.54	3.17	2.02	2.58	3.18	4.18	4.64	10.68

eccentric evertors at 120°/s (r = –.910, p = .032) Table 5. But in any position, there didn't appear to relate balance and isokinetic strength (WK/BW) of ankle eccentric and concentric evertors Table 6.

The most frequently injured site of the body in female hockey players is the lower limb, and the most prevalent types of injuries are ankle sprains[14]. Strengthening the evertor muscles and tendons is a key component in the prevention of ankle sprains; particularly, the eccentric muscle action of the peroneus longus and brevis muscles is a critical factor that complements the role of the lateral ligaments[15–17]. The peroneal muscles play a role as the primary evertors of the foot; moreover, their more important role is the maintenance of foot position during movement and functional activity[18]. However, in this study, the static and dynamic balance ability of only forwards was significantly associated with eccentric strength of evertors at 120°/s. This is important because forwards score goals and create offensive opportunities, and therefore need the fastest movements for passing the defenders.

However, our findings showed that the isokinetic strength of evertors concentrically and eccentrically of the ankle was not greatly relevant to static and dynamic balance ability in defenders and mid fielders. Further studied are required for identifying the relationships between the isokinetic strength of evertors concentrically and eccentrically of the ankle and balance ability in defenders and mid fielders, further studies are required.

3.3 The Correlation between Balance and Isokinetic Strength of the Concentric and Eccentric Dorsi Flexors of the Ankle

In forwards, SI was significantly related to the isokinetic strength (PT/BW) of the ankle eccentric dorsi flexors at 90°/s (r = –.892, p = .042). In mid fielders, SI was significantly related to the isokinetic strength (PT/BW) of the ankle concentric dorsi flexors at 60°/s (r = .897, p = .015), and TCT was significantly related to the isokinetic strength (PT/BW) of the ankle concentric dorsi flexors at 120°/s (r = –.862, p =

Table 5. The correlation of balance and isokinetic strength (PT/BW) for the ankle concentric and eccentric evertors by playing position

		Concentric evertors				Eccentric evertors			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	SI	–0.587	–0.496	–0.377	–0.473	–0.621	–0.254	0.039	–0.292
	TCT	0.096	–0.013	–0.082	0.038	0.504	0.027	0.012	0.264
FW	SI	–0.387	–0.581	–0.522	–0.499	–0.275	–0.496	–0.818	–0.925*
	TCT	–0.391	–0.592	–0.698	–0.661	–0.179	–0.563	–0.759	–0.910*
MF	SI	–0.488	–0.264	–0.441	–0.322	–0.454	–0.338	–0.388	–0.253
	TCT	0.125	0.493	0.413	0.384	0.166	0.462	0.353	0.374

***p<.05, **p<.01**

Table 6. The correlation of balance and isokinetic strength (WK/BW) for the ankle concentric and eccentric evertors by playing position

		Concentric evertors				Eccentric evertors			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	SI	–0.486	–0.609	–0.635	–0.552	–0.628	–0.364	–0.071	–0.273
	TCT	0.011	0.044	0.014	0.108	0.636	0.052	–0.006	0.465
FW	SI	–0.638	–0.667	–0.514	–0.502	–0.542	–0.668	–0.852	–0.866
	TCT	–0.645	–0.710	–0.698	–0.670	–0.305	–0.708	–0.780	–0.857
MF	SI	–0.335	–0.046	–0.290	–0.157	–0.468	0.638	–0.219	–0.139
	TCT	0.425	0.425	0.469	0.475	0.136	–0.538	0.307	0.434

***p<.05, **p<.01**

.027) Table 7. In midfielders, TCT was significantly related to the isokinetic strength (WK/BW) of the ankle eccentric dorsi flexors at 120°/s (r = –.919, p = .010) Table 8.

Ankle sprain injuries are primarily caused by poor balance ability and remain a serious issue in athletes[19,20]. However, the dorsiflexion element of the dynamic defense mechanism-the tibialis anterior muscle-is a smaller, but critical element in the prevention of a lateral ankle sprain[21] The role of the tibialis anterior muscle during this dynamic defense mechanism remains important, particularly when the ankle is in the plantar flexed position[18]. According to the present study, the concentric and eccentric contraction of the dorsi flexors of the ankle in midfielders was relevant to the dynamic balance ability. However, for forwards and defenders, the concentric and eccentric contraction of the dorsi flexors of ankle was not greatly relevant to the static and dynamic balance ability. Further studies are required for identifying the relationship between balance ability and the concentric and eccentric contraction of the dorsi flexors of ankle in forwards and defenders.

Static and dynamic balance are the limiting factors of athletic performance in several sports, and a deficit in balance ability can not only affect the outcome, but also increase the risk of sport injuries[22]. According to the present study, the static and dynamic balance of forwards was closely related to isokinetic strength of evertors and dorsi flexors concentrically and eccentrically, and the dynamic balance of midfielders was closely related to isokinetic strength of dorsi flexors concentrically and eccentrically. This result indicates that the balance ability of hockey players correlated with different isokinetic strength of the ankle as well as the differing types of contraction, depending on the players' field positions. Further studies are required to identify the relationship between balance and isokinetic strength of the ankle in defenders. Training protocols for improving balance ability in order to improve athletic performance and prevent ankle joint injuries should include isokinetic strengthening exercises for the ankle joint, with tailored exercises based on playing position.

Table 7. The correlation of balance and isokinetic strength (PT/BW) for the ankle concentric and eccentric dorsi flexors by playing position

		Concentric dorsi flexors				Eccentric dorsi flexors			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	SI	0.221	–0.630	0.125	0.501	0.223	–0.491	0.008	0.443
	TCT	–0.348	0.147	–0.603	0.099	–0.366	0.236	–0.199	0.160
FW	SI	0.216	0.325	–0.637	–0.068	0.043	–0.117	–0.892*	–0.165
	TCT	0.226	0.363	–0.732	0.046	0.016	–0.062	–0.867	–0.137
MF	SI	0.424	0.897*	0.809	0.633	0.325	0.575	0.573	–0.334
	TCT	0.120	–0.141	–0.473	–0.676	0.001	–0.236	–0.087	–0.862*

***p<.05, **p<.01**

Table 8. The correlation of balance and isokinetic strength (WK/BW) for the ankle concentric and eccentric dorsi flexors by playing position

		Concentric dorsi flexors				Eccentric dorsi flexors			
		at 30°/s	at 60°/s	at 90°/s	at 120°/s	at 30°/s	at 60°/s	at 90°/s	at 120°/s
DF	SI	0.213	–0.562	–0.002	0.456	0.296	–0.448	0.215	0.475
	TCT	–0.058	0.347	–0.254	0.192	–0.457	0.325	–0.318	0.147
FW	SI	0.043	–0.173	–0.744	–0.466	0.152	–0.226	–0.832	–0.374
	TCT	0.114	0.001	–0.767	–0.317	0.132	–0.154	–0.773	–0.115
MF	SI	0.246	0.790	0.827	0.407	0.546	0.544	0.715	–0.224
	TCT	0.424	–0.294	–0.410	–0.807	0.135	–0.066	–0.283	–0.919**

***p<.05, **p<.01**

4. References

1. Lemmink, et al. Evaluation of the reliability of two field hockey specific sprint and dribble tests in young field hockey players. British Journal of Sports Medicine. 2004; 38:138–42.
2. Di Salvo V, Baron R, Tschan H, Calderon Montero FJ, Bachl N, Pigozzi F. Performance characteristics according to playing position in elite soccer. International Journal of Sports Medicine. 2007; 28:222–7.
3. Bressel E. Comparison of static and dynamic balance in female collegiate soccer, basketball and gymnastics athletes. Journal of Athletic Training. 2007; 42(1):42–6.
4. Gstottner M, et al. Balance ability and muscle response of the preferred and non-preferred leg in soccer player. Motor Control. 2009; 13(2):218–31.
5. Zemkova E. Sport-specific balance. Sports Medicine. 2014; 44(5):579–590.
6. Tourny-Chollet C, et al. Isokinetic knee muscle strength of soccer players according to their position. Isokinetics and Exercise Science. 2000; 8(4):187–93.
7. Greve J, Alonso A, Bordini A C PG, Camanho, GL. Correlation between body mass index and postural balance. Clinics. 2007; 62(6):717–20.
8. Sekir U, Yildiz Y, Hazneci B, Ors F, Saka T, Aydin T. Reliability of a funcional test battery evaluating functionality, proprioception and strength in recreational athletes with functional ankle instability. European Journal of Physics and Rehabiliation Medicine. 2008; 44:407–15.
9. Kaminski TW, Buckley BD, Powers ME, Hubbard TJ, Ortiz C. Effect of strength and proprioception training on eversion to inversion strength ratios in subjects with unilateral functional ankle instability. British Journal of Sports Medicine. 2003; 37(4):410–5.
10. Costantino C, Pogliacomi F, Soncini G. Effect of the vibration board on the strength of ankle dorsal and plantar flexor muscles. ACTA BIOMED. 2006; 77(1):10–6.
11. Fox J, Docherty CL, Schrader J, Applegate T. Eccentric plantar-flexor torque deficits in participants with functional ankle instability. Journal of Athletic Training. 2008; 43(1):5154.
12. Mclntyre MC, Hall M. Physiological profile in relation to playing position of elite college Gaelic footballers. British Journal of Sports Medicine. 2005; 39:264–6.
13. Gabbett TJ. GPS analysis of elite women's field hockey training and competition. Journal of Strength and Conditioning Research. 2010; 24(5):1321–4.
14. Murtaugh K. Injury patterns among female field hockey players. Medical and Science in Sports and Exercise. 2001; 33(2):201–7.
15. Willems T, Witvrouw E, Verstuyft J, Vaes P, De Clercq D. Proprioception and muscle strength in subjects with a history of ankle sprains and chronic instability. Journal of Athletic Training. 2002; 37(4):487–93.
16. Glick JM, Gordon RB, Nishimoto D. The prevention and treatment of ankle injuries. American Journal of Sports Medicine. 1976; 4(4):136–41.
17. Heckman DS, Reddy S, Pedowitz D, Wapner KL, Parekh SG. Operative treatment for peroneal tendon disorders. Journal of Bone and Joint Surgery. 2008; 90:404–18.
18. Keles SB, Sekir U, Gur H, Akova B. Eccentric/concentric training of ankle evertor and dorsiflexors in recreational athletes: Muscle latency and strength. Scandinavian Journal of Medicine and Science in Sports. 2014; 24(1): e29–38.
19. Kraemer R, Knobloch K. A soccer-specific balance training program for hamstring muscle and patellar and achilles tendon injuries. The American Journal of Sports Medicine. 2009; 37(7):1384–93.
20. Sims EL, Hardaker WM, Queen RM. Gender differences in plantar loading during three soccer-specific tasks. British Journal of Sports Medicine. 2008; 42(4):272–7.
21. Mitchell A, Dyson R, Hale T, Abraham C. Biomechanics of ankle instability. Part 1: reaction time to simulated ankle sprain. Medicine and Science in Sports and Exercise. 2008; 40(8):1515–21.
22. Zemkova E. Sport-specific balance. Sports Medicine. 2014; 44(5):579–90.