Hip kinematics and muscle activity during inside soccer kick in players with a history of groin pain

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The purpose of this study was to clarify the kinematic characteristics of groin pain (GP). In addition, we investigated the correlations between the kinematics of inside soccer kick movement and muscle activities in the lower extremities. Twenty-four male soccer players (control group, 13; GP group, 11) were instructed to perform maximum inside kick. Our results showed that the adductor muscle activity was maintained from the back swing to the leg acceleration phase in the in GP group but was decreased from the peak value at the back swing to the leg acceleration phase in the control group. In the leg acceleration phase, the adductor muscle activity was significantly higher in the GP group than in the control group. The GP group showed faster adduction/abduction velocity of the kicking leg in all kicking phases than the control group.

Keywords: Groin injury, kicking, motion analysis

INTRODUCTION

Soccer is the most popular sport in the world and is associated with various injuries (Junge & Dvořák, 2002). In recent years, incidence of groin pain (GP) in soccer players has increased (Mayer et al., 2008). Indeed, the Union of European Football Associations reported that during the six years from 2001 to 2007, 64% of all injuries were adductor (Ad) muscle injuries and/or GP, of which 15% were recurrences (Werner et al., 2009). Studies have reported that GP prevents patients from practicing/competing for a long time, and its high recurrence rate hinders the athletic improvement of players (Davis et al., 2010). Consequently, prevention of the occurrence and recurrence of GP is crucial for improving soccer performance. To develop strategies for preventing recurrent GP, clarification of the potential risk factors of GP is warranted. As previously reported, functional impairment such as limited range of motion of the hip joint, and weakness and/or imbalance of the lower extremity muscles cause recurrent GP (Mens et al., 2006). Moreover, biomechanical impairment in the kicking ball motion should cause GP (Davis et al., 2010; Schilders et al., 2009). Functional impairments have been speculated to be related to the characteristics of the kicking motion that causes GP (Charnock et al., 2009). However, the relationship between the two factors is still unclear. Against this background, the relationship between functional impairment and the biomechanical characteristics of ball kicking in GP patients should be clarified in order to provide useful evidence for preventing recurrent GP.

METHODS

Participants

Thirteen healthy well-trained male collegiate soccer players and 11 well-trained male collegiate soccer players with a history of GP in kicking participated in this study. The inclusion criteria were as follows: belonging to a varsity soccer team, having no neurological problem, having no current Ad muscle pain, and having no other diagnosed injuries.

Muscle activity

Muscle activity was measured by using surface electromyography (EMG; ME6000, Mega Electronics Ltd.). Muscle activity was measured in eight test muscles, including the Ad and biceps femoris(BF) of the kicking leg, the gluteus maximus(GM) and gluteus medius(gm) of both legs, the obliquus externus(OE) of the supporting leg, and the rectus abdominis of the abdomen(RA). The EMG signal was considered as the root mean square value until ball impact. Based on previous research, EMG data were rectified and then filtered through a recursive bandpass filter with cutoff frequencies of 450 and 8 Hz (Schilders et al., 2009).

Kicking motion

Kicking motion was observed by using 16 single-optical cameras (Vicon MX, Vicon Motion Systems). Kicking motion was recorded by using 16 synchronised cameras at a sampling frequency of 250 Hz. After a short warm-up, each participant was instructed to perform an inside kick with full force of the foot, on a ball placed 2 m forward at a run-up angle of 0°. Motion data included three-dimensional coordinates that were valued by using the motion capture software. In accordance with previous studies, the three kicking phases, namely back swing, leg cocking, and leg acceleration, were defined. Kicking motion was analysed by using motion analysis software (Visual 3D version 4, C-Motion, Inc.).

Statistical analysis

The experimental data are shown herein as mean ± SD. In addition, two-way analysis of variance was used to test for significant differences in joint angle, angular velocity, and muscle activity between the groups. In all the tests, the statistical significance level was set at a risk rate of <5%. All data were coded and analysed by using SPSS version 22.0 (SPSS Inc.).

RESULTS

- Ad muscle activity significantly differed between the GP and control groups ($F_{[1,22]} = 5.68$, P<0.05). Ad muscle activity demonstrated a significant simple main effect in all the kicking phases and in both groups. Ad muscle activity was maintained from the back swing to the leg acceleration in the GP group. In the control group, it showed its maximum value at the back swing and then decreased. In the leg acceleration phase, Ad muscle activity was significantly higher in the GP group than in the control (Table I).

Table I. Muscle activity in soccer inside kick

(%)		Kicking phase: Back-swing Mean ± SD	Leg-cocking Mean ± SD	Leg-acceleration Mean ± SD	ANOVA results: phase	group	int
Ad	gp	19.8 ± 9.7	24.4 ± 5.5	17.7 ± 12.6	p<0.05	p<0.05	p<0.05
	con	25.1 ± 9.9	20.7 ± 9.2	8.6 ± 6.7			
BF	gp	11.2 ± 5.0	15.9 ± 7.8	21.3 ± 9.1	p<0.001	n.s.	n.s.
	con	14.1 ± 6.7	15.1 ± 6.2	23.5 ± 6.2			
OE	gp	12.9 ± 8.5	27.5 ± 9.1	19.1 ± 9.4	p<0.001	n.s.	n.s.
	con	11.4 ± 8.2	29.6 ± 8.2	20.1 ± 7.1			
RA	gp	14.9 ± 8.5	25.3 ± 11.0	11.8 ± 6.9	p<0.001	n.s.	n.s.
	con	17.1 ± 12.3	28.4 ± 7.5	20.1 ± 6.9			
*GM	gp	18.6 ± 8.3	19.6 ± 8.8	20.9 ± 12.5	n.s.	n.s.	n.s.
	con	17.3 ± 6.2	22.9 ± 11.9	24.9 ± 13.0			
GM	gp	18.3 ± 5.8	27.3 ± 8.8	15.6 ± 5.7	p<0.001	n.s.	n.s.
	con	18.6 ± 6.8	24.1 ± 10.1	18.0 ± 9.9			
*gm	gp	19.5 ± 8.6	11.7 ± 8.8	15.9 ± 11.5	n.s.	n.s.	n.s.
	con	18.3 ± 8.8	13.9 ± 8.3	16.7 ± 11.6			
gm	gp	13.3 ± 4.8	21.8 ± 4.8	17.2 ± 10.2	p<0.05	n.s.	n.s.
	con	16.0 ± 8.5	18.8 ± 8.1	16.0 ± 8.8			

*:Kicking foot

The hip joint adduction/abduction angular velocity of the kicking leg significantly differed between the GP and control groups ($F_{[1,22]} = 5.6$, $P < 0.05$). The hip joint adduction/abduction angular velocity from toe-off to ball impact was significantly higher in the GP group than in the control group (Table II).

- The pelvic lateral/medial lean angle significantly differed between the GP and control groups ($F_{[1,22]} = 6.9$, $P < 0.05$). It was tilted in different directions, that is, medially in the control group and laterally in the GP group throughout all the kicking phases. In addition, the pelvic lateral lean angle in the time of ball impact was significantly higher in the GP group than in the control group. The pelvic anterior/posterior lean angle showed significant main effects in all the kicking phases and in both groups ($F_{[1,22]} = 7.5$, $P < 0.05$). Compared with the control group, the GP group had smaller pelvic anterior angle from toe-off to maximum hip extension but larger pelvic anterior angle after maximum knee flexion (Table II).

Table II. Hip joint angular velocity of the kicking leg and pelvic angle

		Kicking phase				ANOVA results		
(deg/sec)		Toe off	Max hip extension	Max knee flexion	Ball impact	phase	group	int
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD			
Kicking foot								
Hip flex/ext	gp	-220.1 ± 63.1	-1.5 ± 30.3	484.1 ± 101.1	72.3 ± 63.6	p<0.001	n.s.	n.s.
	con	-195.8 ± 84.3	-4.8 ± 22.4	447.1 ± 71.9	30.0 ± 64.1			
Hip add/abd	gp	-69.2 ± 55.4	-185.3 ± 26.7	130.2 ± 109.3	202.9 ± 95.7	p<0.05	p<0.05	p<0.05
	con	-45.4 ± 40.1	-134.9 ± 84.7	2.7 ± 89.9	110.6 ± 94.7			
Hip exter/inter	gp	1.1 ± 153.3	-87.2 ± 113.1	-164.5 ± 120.9	555.6 ± 142.4	p<0.001	n.s.	n.s.
	con	12.2 ± 151.5	-140.6 ± 124.9	-76.7 ± 125.5	396.2 ± 282.0			
(deg)								
pelvis								
Anterior/posterior	gp	26.8 ± 4.9	12.9 ± 5.4	-2.2 ± 5.3	-24.5 ± 5.4	p<0.001	p<0.05	n.s.
	con	32.7 ± 5.0	21.7 ± 6.2	2.6 ± 5.8	-18.23 ± 5.3			
Lateral/medial	gp	-3.4 ± 2.6	1.5 ± 2.6	1.9 ± 2.4	1.1 ± 3.9	p<0.001	p<0.01	p<0.05
	con	-5.0 ± 4.1	1.2 ± 2.6	-2.5 ± 1.8	-5.4 ± 2.7			
External/internal	gp	-30.9 ± 3.8	-25.6 ± 4.9	-18.5 ± 8.5	-10.39 ± 13.2	p<0.001	n.s.	n.s.
	con	-28.0 ± 5.7	-24.4 ± 5.6	-16.8 ± 8.5	-10.13 ± 9.0			

DISCUSSION

The Ad muscle activity decreased towards ball impact in the control group but remained high in the GP group. According to previous studies, over-activity of the Ad muscle during a kicking motion is a contributing factor to the occurrence of GP (Brian et al., 2009). In the present study, because Ad muscle activity remained high during the kicking movement towards ball impact in the GP group, the risk of recurrence of GP was possibly increased. The hip adduction/abduction angular velocity of the kicking leg in the GP group was faster during the kicking movement towards ball impact. According to previous research, GP has been associated with repeated stress on the Ad muscle during kicking motion (Davis et al., 2010). The soccer players in the GP group in the present study also had a distinctive kicking pattern, which depended on hip joint adduction/abduction of the kicking leg. That is, the characteristics of the inside kick movement in the GP group can be considered as the cause of GP. Pelvic lateral/medial lean angle significantly differed between the GP and control groups. In addition, the pelvic anterior/posterior lean and external/internal rotation angles showed significant main effects in all the kicking phases. The GP group in the present study had a smaller pelvic anterior angle during kicking motion than the control group. Anatomically, the anterior aspect of the pelvis is involved in moving the hip joint backwards. Thus, we can infer that in individuals with GP, the hip joint of the kicking leg is less likely to move backwards. As described earlier, if the hip joint cannot effectively move backwards, the muscles around the hip joint must work harder to support the kicking motion. In addition, the GP and control groups demonstrated a significant difference in pelvic lateral/medial lean angle. According to previous studies, the pelvic lateral/medial lean angle is essential for performing a kicking motion (Levanon & Dapena, 1998). In other words, the pelvis and hip should be raised in order to produce an efficient kicking motion. To that end, the pelvic lean angle should be directed towards the supporting leg. However, in the GP group in the present study, the pelvis was tilted towards the kicking leg. Based on these results, individuals with GP cannot effectively raise the pelvis during the kicking motion. This inefficient movement has been speculated to be a contributing factor to the occurrence of GP.

CONCLUSION

Previous research studies did not reveal the features of the kicking motion and muscle activity that were associated with the high relapse rate of GP in the past. In the present study, we conducted an experiment to target the history of GP. The following findings were obtained in the present study: First, the Ad muscle activity in the GP group showed over-activity during the inside kick movement. Second, the small pelvic anterior tilt in the GP group during the kicking movement was likely related to the limited hip joint extension. Finally, the soccer players in the GP group could not raise the pelvis and hip to produce an efficient kicking motion. As mentioned previously, the Ad muscle strength was low in the control group but remained high until ball impact in the GP group. In addition, the hip joint adduction/abduction angular velocity of kicking leg in the GP group was faster in all kicking phases. In other words, individuals with GP swing their kicking legs by increasing hip adduction/abduction and Ad muscle activity. These new findings may help in developing strategies for preventing the recurrence of GP.

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