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The comparison of selected kinetic factors during a cross-cutting maneuver in soccer players with athletics groin pain and healthy ones: Implications for injury prevention

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Abstract

Introduction: This study aimed to compare selected kinetic factors during a cross-cutting maneuver in soccer players with athletics groin pain (AGP) and healthy ones.

Martials and Methods: Twenty-eight soccer players (healthy group (n=14) and AGP group (n=14)) who take part in the first and second division league took part in this study. A force plate at 1000 Hz sampling rate was used to evaluate the ground reaction force, rate of force development, vertical impulse and symmetry index during the cross-cutting maneuver. The MATLAB and ORIGIN PRO software were used to filter and process the force plate data. The independent sample t-test was used to compare healthy groups and AGP results.

Results: The results showed the significant differences in the peak of ground reaction force (P=0.023), symmetry index (P=0.01), and rate of force development (P=0.031) in the medial-lateral direction of the dominant limb in a group with AGP. The peak of the vertical ground reaction force of the non-dominant limb was significantly higher in the AGP group (P=0.004).

Conclusion: It seems that groin pain may change the kinetic profile, which puts the athletes at the potential risk of overuse injuries in the lower extremity. It is also recommended to utilize the output of the current study as an index for back to sports index, and the rehabilitation progress should be continued to reduce symptoms and recurrence of injury up to the proper symmetry.

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1. Introduction

Athletic groin pain (AGP) is one of the most frequent injuries among athletes, which has shear movements, starting, and constant change of direction [1]. Pain uses compensatory mechanisms to modulate it and affects lower extremities movements pattern, which leads to a prolonged pain healing process [2]. The prevalence of this complication in soccer was declared around 45% and caused the loss of more than half of the twenty-two games during the season and costs over 1.7 million Australian dollars due to the loss of athletes [3]. The groin pain significantly affects athletes' performance in daily life, sports performance, and quality of life [4]. Any changes in function and health status due to pain in the hip and pelvis based on the fundamental relationship with adjacent limbs and joints can affect the posture and movement pattern [5].

Sports injuries often occur during running, jumping, or shear movements [6]. Shear movements are essential components of successful performance in sports activities [7]; For example, a soccer player typically makes 726±203 cutting maneuver during a soccer match [8]. Cutting movements are regularly adopted to evaluate the kinematics and kinetics of the lower extremities joints in the risk of ligament injury assessments, which usually take place during the single-foot strike phase [6]. In addition, at the initial 25% of the heel contact phase, a deceleration component is associated with knee valgus [9]. The cutting maneuver are usually accompanied by the fully opened knee and the tibia's internal or external rotation, leading to the rupture of the ankle ligaments. The lateral ankle ligaments have the most outstanding share of joint stability and prevent the joint from abnormal movements, excessive torsion, rotation, and foot twisting [10].

The leading cause of 85% of ankle ligament injuries is a lateral ankle sprain [11] due to large supination torque. In addition, increased vertical loading rate at the heel contact is associated with various injuries [12], including soft tissue injuries [13], tibial stress fractures [14], patelo-femoral syndrome [15], and plantar fasciae [16]. In soccer, agility and changing of direction are necessary to make appropriate adjustments in the body for an unexpected situation, which is done by changing the speed and position of the center of mass relative to the center of pressure, and ground reaction force [2, 17]. These adjustments also alter the pattern of the ground reaction force components at the end of the body chain between the foot and the ground. Studies indicated that the kinetic profile, such as time to the peak and the vertical ground reaction force were significantly higher in patients with groin pain than healthy individuals, which may put the athletes at further risk of injuries [18, 19]. The mechanisms and strategies assessments contribute to injuries will lead to the design of appropriate injury prevention programs for proper identification, prevention, and treatment of this complication [7].

To understand the defect of motion control in these modifications, it is necessary to design a study to investigate the pattern of the kinetic profile during the cutting maneuver. However, no studies have been conducted in this field in patients with groin pain, so this study aimed to compare selected kinetic factors during a cross-cutting maneuver in soccer players with athletics groin pain (AGP) and healthy-ones.

2. Materials and Methods

The current semi-experimental study was performed following the Helsinki Declaration regulations regarding research on human subjects and ethical procedures approved by the Research Ethics Committee of the Sports Science Institute with the code: IR.SSRC.REC.1400.020.

The subject of the present study included healthy and those who have athletic groin pain in soccer who requires a constant change of direction, running, jumping, and repeated start movements [3]. Based on previous inquiry and using G-Power software version 3 designed by Kiel University made in Germany with a statistical power of 0.65, an effect size of 0.5, and an α & β error of 0.34, fourteen men soccer players were considered [1, 20]. Subjects in the healthy group included soccer players in the first and second-division leagues. In addition, the group with athletic groin pain was selected voluntarily with the cooperation of the Iranian Football Medical Center (IFMARC) and sports physiotherapy rehabilitation centers in Tehran and Alborz province. The participants were informed about the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information, and they were free to leave the study whenever they wished.

2.1. Inclusion and Exclusion criteria

Inclusion criteria in the AGP group were: having unilateral tenderness or pain into the adductor tendons (insertion onto the pubic bone) [21], groin pain during or after sporting activities [3, 22], positive adductor squeeze test [23], lack of pain in adjacent joint in latest six months [5], participating in sports activity despite the pain [1]; and healthy group: no history of lower extremities injuries in the past year [2], negative adductor squeeze test [23] and general health [1, 5]. In addition, exclusion criteria also included: history of low back pain in the past year [2], neurological symptoms in the lower extremities [24], history of fracture or dislocation of pelvic and arthritis [25]; and in order to eliminate the biased data, the athletes who have pain perception of less than 3 and more than 7 on the VAS scale were excluded from the testing process.

2.2. Pain perception assessments

The visual analogue scale (VAS) measured pain [26]. This scale is commonly used to measure the perceived pain severity with ICC=0.81. This scale is composed of a straight horizontal line as long as 100 mm with the phrase "lack of pain perception" written on one end and "the most severe pain possible" written on the other. After explaining, the patient marked the current pain level by choosing a number from 0 (no pain) to 10 (unbearable pain), they perceive most of the time on this scaled line [2, 27]. The demographic and pain feature of participants are presented in Table 1.

2.3. Data collection procedure

A Kistler brand trademark (9260AA6 Model 30*50 CM-Made in Switzerland) force plate measured kinetic components with a 1000 hertz sampling rate. The kinetics factors included of: the peak of ground reaction force, the rate of force developments, vertical impulse, and symmetry of this data were evaluated during cross-cutting maneuver.

The peak ground reaction force was evaluated in vertical, medial-lateral, and anterior-posterior directions. The rate of force development (RFD) is also calculated to correspond to the peak ground reaction force [28]. The area allocated under the force-time diagram after heel contact up to the peak of vertical ground reaction force (VGRF) is considered vertical impulse [29]. The symmetry of data was also obtained from Robinson and Nigg formula [30].

$$\text{SI Index} = 2\times(L-R)/(L + R)$$

2.4. Cross-cutting maneuver

In cross-cutting maneuvers and after the heel contact, the subject should do the cutting maneuvers at 60 degrees toward the direction [2] (Figure 1).

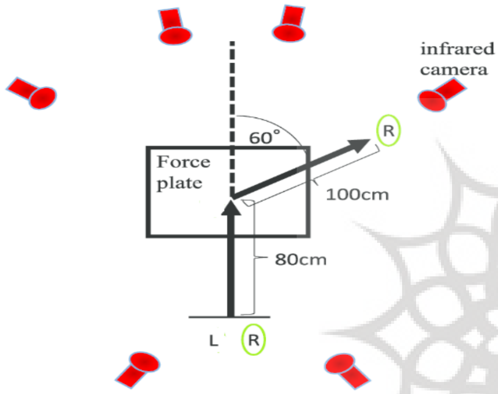


Figure 1. Cross-cutting maneuver schematic

The subject did these maneuvers three times with their dominant and non-dominant limb intervals with 1-min rest, and the mean data was considered as the main record [31]. The point is considered heel contact when the vertical ground reaction force exceeds 10 N [28].

2.5. Data analyses and statistic

Kinetic data were filtered with Butterworth 4th order with a cut of frequency of 30 hertz [32]. MATLAB software version 2021 was used to filter and process the force plate data, and ORIGIN software version 2021 made in the USA was used to present the output information [7]. SPSS software version 25 and the Shapiro-Wilk test to check out the normality of the data and independent t-test were used to compare the results between healthy groups with AGP at a significance level of 0.05,

3. Results

Demographic characteristics and baseline of the subjects are presented in Table 1. The Independent t-test showed no significant difference between age, height, weight, and subjects' body mass index.

Table 1. Mean and standard deviation of demographic characteristics and baseline of subjects (n=14)

Variables	Mean ± Sd Groups		*P*
	Healthy	AGP	
Age (y)	22.5±1	22.5±2	0.17
Height (m)	1.78±0.05	1.75±0.06	0.061
Weight (kg)	77±10	75±7	0.552
BMI (kg/m^2)	23.5±2.7	24.1±2.76	0.539
Pain perception (VAS)	0	4.8±0.9	0.0001<

The results indicated that the ground reaction force of medial-lateral direction in the dominant limb (P=0.023) and the vertical ground reaction force of the non-dominant limb (P=0.04) in the groin pain group were significantly higher than the control group. The independent t-test related to the peak of ground reaction forces is presented in Table 2.

The results also showed that subjects in the groin pain group had higher vertical impulse in the dominant limb during the cutting maneuver, but the difference was not significant (P= 0.06). Also, there were no significant differences between groups in none dominant one (P=0.88; Figure 2).

The results showed that the difference in the symmetry of the ground reaction force in the medial-lateral direction of the group with chronic groin pain was significantly higher than the control group (*P*= 0.01).

Finally, the results indicated that the AGP group has significantly higher RFD in the medial-lateral direction (*P*= 0.031). However, there were no significant differences in the anterior-posterior and vertical directions (Figure 3).

Table 2. The comparison of the relative ground reaction force between groups (n= 14)

Variables		Mean ± Sd Groups Healthy	Mean ± Sd Groups AGP	T	*P*
The relative ground reaction force	Anterior–posterior in dominant limb	0.21±0.045	0.25±0.07	1.55	0.133
	Anterior–posterior in none-dominant limb	0.25±0.05	0.28±0.08	1.22	0.233
	Medial–lateral in dominant limb	0.28±0.09	0.4±0.17	2.41	0.023*
	Medial–lateral in none-dominant limb	0.27±0.07	0.32±0.11	1.41	0.170
	Vertical in dominant limb	2.13±0.30	2.36±0.34	1.83	0.07
	Vertical in none-dominant limb	2.06±0.29	2.46±0.35	3.18	0.004*

*Significant at 0.05 level

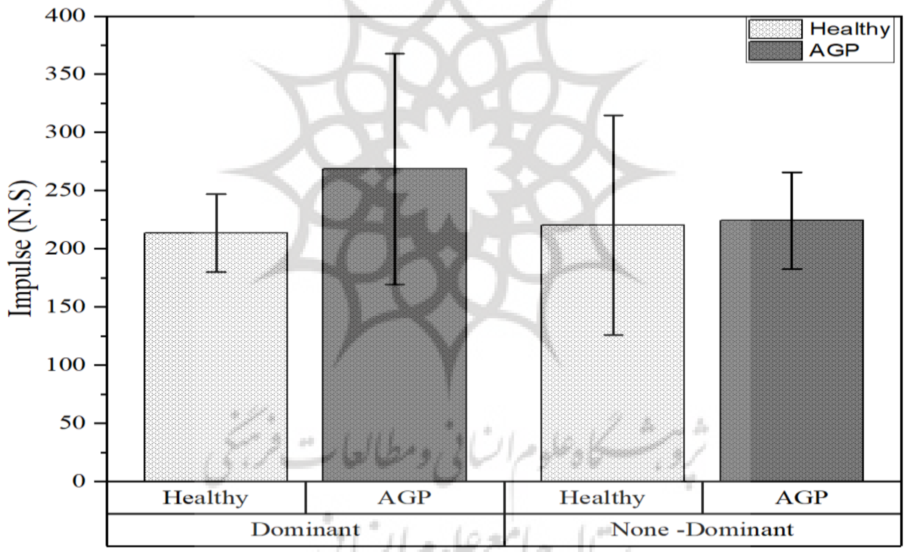
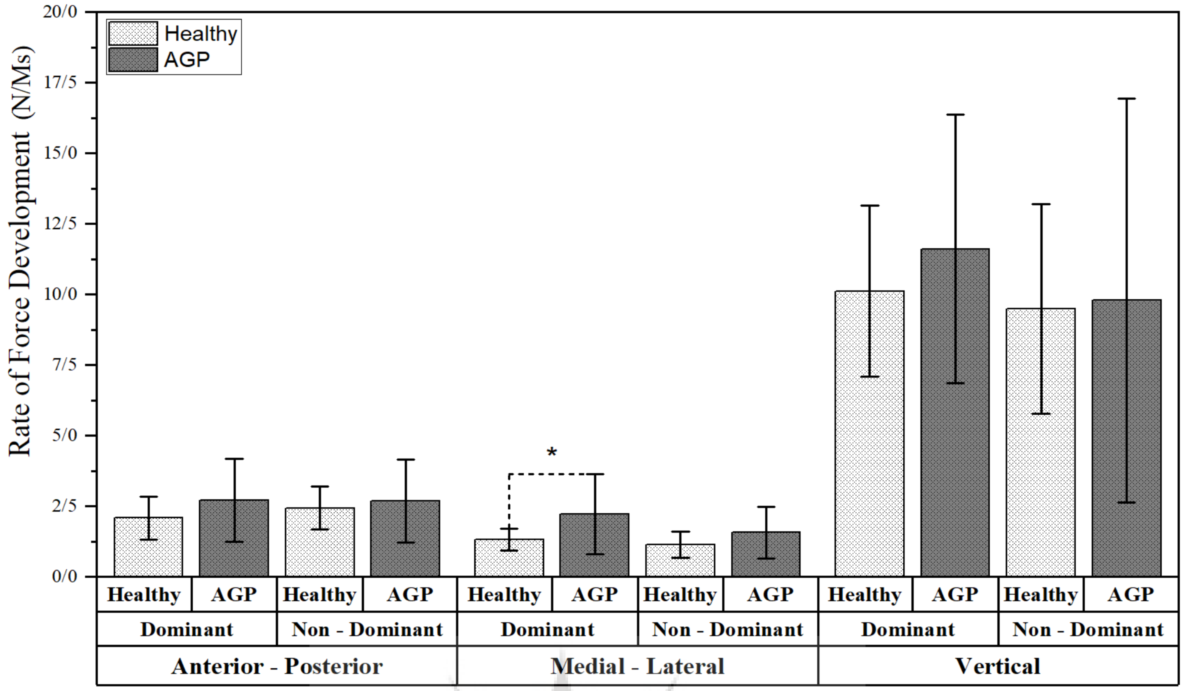


Figure 2. The comparison of the vertical impulse between groups

Table 3. The mean and standard deviation of the symmetry of kinetic data between groups (n= 14)

Variables		Mean ± Sd Groups Healthy	Mean ± Sd Groups AGP	T	*P*
The symmetry index of	Peak of GRF in the anterior-posterior direction	0.26±0.16	0.27±0.23	0.161	0.873
	RFD in the anterior-posterior direction	0.38±0.25	0.57±0.58	1.15	0.259
	Peak of GRF in the medial- lateral direction	0.23±0.13	0.56±0.43	2.78	0.01*
	RFD in the medial-lateral direction	0.29±0.23	0.53±0.52	1.53	0.138
	Peak of GRF in the vertical direction	0.08±0.07	0.11±0.09	0.8	0.426
	RFD in the vertical direction	0.29±0.23	0.45±0.41	1.23	0.229
	Vertical impulse	0.2±0.19	0.33±0.37	1.15	0.258

*Significant at 0.05 level



*Significance at 0.05 level.

Figure 3. The comparison of the rate of force development between groups

4. Discussion

This study aimed to compare selected kinetic factors during a cross-cutting maneuver in soccer players with athletics groin pain (AGP) and healthy ones. The results indicated that pain could change kinetic profile during the cutting maneuver. The results show a significant 30% increase in the medial-lateral and 15% in the groin pain group's vertical ground reaction force component. In the cutting maneuver, the loading is applied more inwards and forefoot. However, as soon as unexpected tensile stress is applied quickly to the ligaments, it causes damage and rupture of these tissues [33].

Furthermore, in the cutting maneuver and at the heel contact, it creates a large lever relative to the joint axis of the subtalar, which leads to a sizeable supination torque, causing the foot to move too much inward, resulting in excessive loading and lateral ankle sprain [7, 34]. It seems that pain could change the ground reaction force pattern during a cutting maneuver. These changes put the athletes at the risk of further lower extremities injuries. This finding supports Coetsee (2016) [18] and Edwards et al. (2017) [19], who reported a higher ground reaction force component in the AGP group.

The impulse index provides valuable information, including the amplitude and duration of applying force [35]. According to the result, although the vertical impulse was higher in the groin pain group, it cannot be concluded that lonely pain changes the vertical impulse on Ipsi-and contralateral side; So, interpretation of present outcomes must be conservatively, and the overall result should be considered with other influential factors such as fatigue, feedforward or muscle activity. This finding agrees with the results of Scholes et al. (2019) [36] and Santoro et al. (2021) [29], who reported higher impulse in a patient with groin pain, but the difference was not significant. It may be because of their task protocol running in Scholes et al. and the change of direction in Santoro's research.

The current study provides novel findings and outlines new kinetic component profiles adding to the literature and existing research on groin pain. The results showed over 50% difference in the symmetry of the ground reaction force in the medial-lateral direction of the group with chronic groin pain. According to the research findings, this asymmetry caused by pain affects the motor control approaches of soccer players. The symmetry index is one of the criteria for assessing the biomechanical performance status during sports activities. Asymmetry is a pathological factor, and symmetry or reduction of asymmetry in injured people are used as an indicator to determine the back to sport time. The rehabilitation progress should be continued to reduce symptoms and recurrence of injury up to the proper symmetry. We can utilize the current study's output as input for the planning program by coaches to control and eliminate this inappropriate factor.

Last but not least, it seems that pain causes higher RFD characteristics, which put the athletes at the risk of further injuries. Furthermore, since body tissues are viscoelastic, their loading response is time-dependent, and damage decreases at lower loads; In the other words, at a lower load, a specific force is applied to the tissue for a longer period of time, and the probability of tissue damage is reduced [12]. Therefore, it seems that the increase in RFD of the medial-lateral direction in the groin pain group increases the risk of lateral ankle ligament injuries due to the consequent supination torque [7, 12].

The authors declared some limitations in the present study, such as the unisex gender of subjects. However, given that gender differences such as the lower center of gravity, wider pelvis, and jumping and cutting mechanics in both sexes, it is not reasonable to expect that the present study results cannot be generalized to women. For as much as the feedforward and feedback mechanism and motor control play an essential role in moderating the external forces before and after heel contacts, recording muscle activity in the core and lumbopelvic region should be considered simultaneously during movements.

5. Conclusion

It seems that groin pain changes the kinetic profile, and related changes may put the athletes at the potential risk of ankle sprain injuries. Nevertheless, it suggested that the researchers do the same survey with other cutting maneuvers via a higher statistical population to achieve more data resources to eliminate all the existing ambiguities, It is also recommended to utilize the output of the current study as back to sports index, and the rehabilitation progress should be continued to reduce symptoms and recurrence of injury up to the proper symmetry.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The ethics committee approved this study from the Research Ethics Committees of

Sport Sciences Research Institute (SSRI).

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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