EFFECT OF PLAYING SURFACE ON KINEMATIC MOVEMENT PATTERNS OF KNEE AND ANKLE IN FEMALE FOOTBALL PLAYERS

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The purpose of this study was to identify the effect of playing surface on kinematic movement patterns of knee and ankle. Eight female university football players performed 16 unanticipated cutting movements on each surface (natural turf; 3G artificial turf). Kinematic data of knee and ankle joint were collected. Comparisons between the surfaces showed no differences at the ankle joint. However, significantly higher values of knee internal rotation were observed on natural turf. Additionally, effect sizes showed a consistent tendency of higher knee valgus on natural turf. These findings indicate an influence of playing surface on kinematic movement pattern of the knee joint in the frontal and transverse plane.

KEY WORDS: artificial turf, natural turf, cutting manoeuvre, lower limb, injuries.

INTRODUCTION: Recently, artificial turf (AT) is used as substitute for natural turf (NT) in many sports. Lower maintenance costs, better reliance to tough climatic conditions, which provides longer playing hours, as well as a multi-purpose application, are benefits which lead to an increased AT-pitch utility. Commonly, athletes prefer playing on NT over playing on AT. Andersson, Ekblom, & Krustrup (2008) identified, via a subjective questionnaire, a negative perception of AT based on the feeling of “poorer ball control and greater physical effort”. This stands against objective observations and physiological measurements discovering no overall differences between AT and NT, either in movement patterns like sprinting, jumping and agility performance or in physiological response like heart rate or blood lactate (Hughes et al., 2013), which indicates that player perceptions of needing an increased effort on AT have no physiological basis. Besides the possible change in movement patterns, a different surface might induce different injury patterns, but there are inconsistent findings in relation to the effect of AT and NT on the incidence of injuries. Whereas the majority of the studies (Ekstrand, Hagglund, & Fuller, 2011; Fuller, Dick, Corlette, & Schmalz, 2007a, 2007b) determined no differences in overall injury risk for both genders or lower injury risk on AT (Meyers, 2013), Steffen, Andersen, & Bahr (2007) identified among female football players a tendency of higher risk for ankle injuries and knee injuries on AT. However, these results are only based on counting injuries incidence over a certain period of time without explaining cause and effect of the surface. Additionally, female football players showed decreased flexible coordination patterns and less ability to adapt to the environmental perturbations compared to their male counterparts, which might lead to increased injury incidence (Pollard, Heiderscheit, van Emmerik, & Hamill, 2005). As a result, in order to enhance the understanding of how female footballers respond to different surfaces it appears necessary to measure knee and ankle kinematics during sport-specific movements (e.g. cutting).
Cochrane, Lloyd, Buttfield, Seward, & McGivern (2007) found out, that 37% of the non-contact ACL injuries occurred during cutting manoeuvre, followed by 32% in landing, 16% land and step, 10% stopping/slowing and 5% crossover cut manoeuvres. Moreover, according to Besier, Lloyd, & Ackland (2003), unanticipated cutting manouvers are more likely to represent the movements during a game situation and are described with an increased risk of injury compared to anticipated cuttings.
Therefore, the purpose of this study was to investigate the lower limb kinematics on different surfaces in female football players during an unanticipated cutting manoeuvre. This may provide further knowledge in the mechanism of injury risk in football.

It was hypothesized that playing surface affects lower limb kinematics of female football players during an unanticipated cutting manoeuvre.

METHODS: Eight female university level football players (age: 21.5 ±2.1 years; height: 162.8 ±7.1 cm; weight: 66 ±60.3 kg; football experience: 13.3 ±4.1 years) participated in the study. All athletes kicked the ball with the right-foot as their preferred leg and were free from injury. The preferred leg was defined as the leg, which the players automatically use for a single-legged jump. Each participant wore her own football boots and changing of boot type between the surfaces was not permitted.
Data collection took place at the Cardiff Metropolitan University, Cyncoed Campus, subdivided into a testing session on a NT and a testing session on a 3g AT.

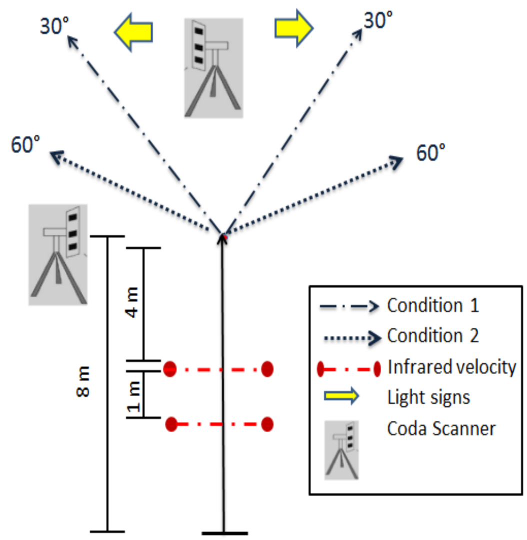

Figure 1: Experimental set-up

An individual warm-up was performed by each participant. After five customisation trials to familiarize the participants with the movement and the predetermined approaching speed of 4-5m/s, every athlete performed 16 trials of an unanticipated (to the right or left side) cutting manoeuvre. The movement contained an acceleration phase of maximum 8 m before cutting with a change of direction in a 30° (condition 1) or 60° (condition 2) angle followed by a 5 m acceleration phase before decelerating and finishing the manoeuvre. All players had to perform four trials for each condition to each side on both surfaces. The order of surfaces, cutting angle and the direction of the cut were performed in a randomized order. The direction of the cut was indicated by light sign in the acceleration phase of the cut. A trial was declared as successful when predetermined speed and cutting point was hit.
Kinematic data were collected using an outdoor 2-scanner 3D motion capture analysis system (CodaSport CXS System, Charnwood Dynamics Ltd., UK) and were sampled at 200 Hz. Fourteen active markers and 2 clusters were placed on anatomical landmarks of the left lower limb to calculate knee and ankle joint angles in the sagittal, frontal and transverse planes. Scanners were positioned so that each cluster was detected by at least one scanner throughout the whole cutting-movement. Approach velocity was determined via two pairs of infrared velocity timing gates (SMARTSPEED, Fusion Sport International, Australia), placed at the 5th m before the cutting point (Figure 1). All data were normalized to 100% of the stance phase of the cut. Stance phase was defined as the period from initial contact of the foot to toe off and determined using kinematic data of the 5th MTJ and 2nd IPJ (Ast et al., 2013). Data were analysed for the first 20% of the stance phase (20% of SP) as early deceleration is the point in the cutting cycle where the majority of non-contact ACL injuries are thought to occur (Boden, Dean, Feagin, & Garrett, 2000).
Average ankle and knee angles in sagittal, frontal and transversal plane during early deceleration were calculated to describe the joint angles during that phase (Sigward & Powers, 2006). Additionally, the ankle and knee angles at touchdown (TD) and range of motion (ROM) during the early deceleration were calculated for the 3 planes. As means of statistical measure a two-way (cutting angle, surface) ANOVA was performed by using SPSS statistical software (Chicago, IL, USA). Significance levels were set at $p \leq 0.05$. Effect sizes were calculated using the partial eta squared (small: $0.01< \eta^2_p<0.05$; medium: $0.06< \eta^2_p<0.13$; large: $\eta^2_p>0.14$) and Cohen's d value (small: 0.2<d<0.49; medium: 0.5<d<0.79; large: ≥ 0.8) due to the low sample number medium and high effect sizes will also be discussed as indicator for movement changes.

RESULTS and DISCUSSION: Global effect turf: Comparisons between surfaces showed no significant differences for the ankle; however, there was a consistent tendency of higher knee valgus and internal rotation values on NT for the 30° cutting with medium and large effect sizes (Table 1). Statistically, only the average knee internal rotation during early deceleration and internal rotation at TD reached the level of significance. The knee internal rotation at TD was 5.5° significantly higher on NT compared to AT, which also applied to a 5.4° higher average value during the early deceleration. On the other hand, the ROM of this value in the first 20% of SP is 1.7° higher on AT compared to NT indicating that the higher average only resulted from the high value at TD.

Table 1
Average knee joint angles and ROM of the first 20% of SP; angles at TD

	Mean (±sd)				**global interaction: turf**			
	NT30	NT60	AT30	AT60	sig.	ηp2	d	
							30°	60°
Valgus								
TD	15.0 (±2.9)	13.6 (±4.5)	11.8 (±5.0)	13.5 (±5.7)	.22	.21	.77	.02
ROM	6.5 (±3.6)	5.5 (±2.8)	4.6 (±1.8)	4.0 (±2.3)	.13	.30	.68	60
average	18.5 (±4.0)	17.3 (±5.2)	14.1 (±5.4)	15.6 (±5.6)	.08	.37	.92*	.31
Int. Rot.								
TD	-13.8 (±8.9)	-11.0 (±10.5)	-8.3 (±12.7)	-8.4 (±11.5)	.05*	.44*	.51*	.23
ROM	4.3 (±2.7)	5.2 (3.8)	6.0 (±2.9)	7.2 (±3.7)	.07	.40	.61	.54
average	-14.8 (±10.3)	-13.3 (±11)	-9.4 (±11.5)	-10.4 (±11.6)	.05*	.45	.49*	.25

*p<0.05

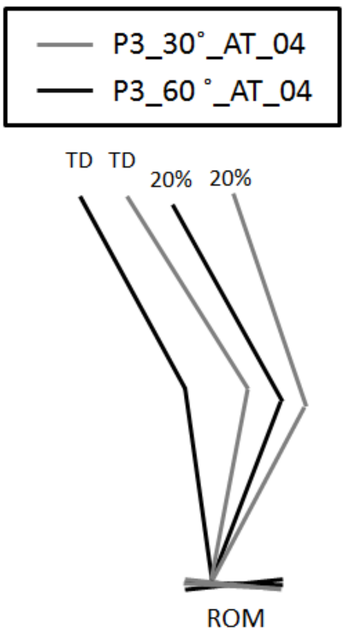

Figure 2: movement profile for participant 3 for the 30° cutting (grey) and 60° cutting (black) on AT

The angle of the knee in the frontal and transverse plane is believed to be an important factor for ACL injuries. According to Cochrane et al. (2007), ACL injuries seems more likely to occur at initial ground contact, but it is still uncertain why and when the injury exactly occurs. As the values for valgus and internal rotation of the knee at TD is higher on NT in this present study, it would support literature results of lower injury risk on AT (Meyers, 2013). However, the ROM of internal rotation of the knee was higher on AT. This on the other hand, requires further researches about the main cause of ACL injuries, to draw a final conclusion about effect of surface on injury risk.

Global effect cutting angle: Cutting angle seems to influence the movement pattern of the athletes in the sagittal plane. There are significant higher values for knee flexion at touchdown for the 30° cutting on both surfaces (NT: 3.5°, AT: 3.4°), which resulted in a decreased range of motion for this parameter for 30° compared to 60° cutting (NT: 5.8°; AT: 3.9°), as the values at 20% of SP are similar for both cutting degrees. That supports our expectation of a higher ROM for the purpose to perform a sharper direction change. In terms of the risk of ACL injuries, these findings might indicate generally a higher risk for the 60° cutting, since Boden et al. (2000) stated that there is a higher injury risk when the knee is close to extension at TD. Additionally, significantly higher values of the ankle dorsiflexion at TD were observed on AT for the 30° cutting.

Interaction: No significant interaction effects between turf and cutting angle were observed.

The effect size (d) indicates medium to high effect sizes for several parameters not stated in the present results.

CONCLUSION: The findings of the present study indicate that playing surface affect only the knee kinematics of female football players. Playing surface seems to change the movement pattern for the 30° cutting movement, concerning a tendency of higher knee valgus and significant higher average internal rotation of the knee during the first 20% of SP and at TD on NT compared to AT. Those parameters are considered as the most common contribution factors of occurring non-contact ACL injuries (Cochrane et al., 2007). Whether the results are beneficial or not concerning injury risk require further investigations. More complex movement like the 60° cutting didn't show any significance between the surfaces anymore. The cutting angle seemed to affect movement pattern in the sagittal plane of knee and ankle joint.

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