

## INFLUENCE OF FOOTBALL BOOT UNDERSURFACE TYPE ON KNEE JOINT ROTATIONAL MOMENTS AND POTENTIAL NON-CONTACT ACL INJURY

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Four pairs of commercially available standardised football boots (two bladed and two studded) were evaluated to determine whether boot undersurface type affects potential non-contact ACL (anterior cruciate ligament) injury. Fifteen professional outfield male football players undertook three trials of a straight line run and sidestep cuts at 30° and 60° with approach velocity 5.5 m·s<sup>-1</sup> - 6.0 m·s<sup>-1</sup> on an approved artificial football surface. Using an eight camera gait analysis system (120Hz) synchronised with a force platform (960Hz), internal rotational knee moments were compared with cadaveric limits for ACL injury. Internal rotational knee moments during straight line running using studded and bladed boots were insufficient for potential non-contact ACL injury, but were significantly greater during sidestep cutting ( $p < 0.001$ ) and capable of potential injury.

**KEY WORDS:** football boot, knee rotation moment, ACL injury

**INTRODUCTION:** The football boot undersurface and foot fixation has been shown to play key roles in knee injury development (Torg and Quedenfeld, 1974; D'Ambrosia, 1985). In football 66% of ACL (anterior cruciate ligament) injuries are non-contact in origin (Nigg and Segesser, 1992). Internal tibial rotational moments alone play a major aetiological role in ACL injury, the risk being similar to internal tibial rotational moments with combined valgus or varus moments (Markolf et al., 1995). There is a paucity of research that has investigated football boot undersurfaces representative of those used in the modern game and potential non-contact ACL injury. Modern football boots, available to amateur and professional players, incorporate undersurfaces with studs or blades, or a combination. Currently FIFA [Federation of the International Football Association] have not provided recommendations regarding injury risk. As a result it is difficult for medical teams to provide advice. The purpose of this research was to quantify knee joint internal/external rotational moments during side-step cutting using studded and bladed football boots on a FIFA approved artificial football surface representative of those used in match situations. Based on ACL critical limits, this study evaluated commercially available studded and bladed football boots to determine whether types of boot undersurface affect non-contact ACL injury potential when football players sidestep cut.

**METHODS:** Fifteen professional outfield male football players of mean age 19.5 years ( $\pm 1.4$ ), mass of 70.1 kg ( $\pm 7.6$ ), UK shoe size of 8.5 ( $\pm 1.2$ ) and stature of 1.76 m ( $\pm 0.06$ ), without history of lower limb injury, with at least two consecutive injury-free seasons participated. Written informed consent was obtained from each player to participate and for use of their clinical data. All were free from any injury for at least two consecutive seasons and had no history of injury requiring hospital admission. Fourteen of the players were right foot dominant. Each undertook three trials of a straight line run (0°) and sidestep cuts at 30° and 60° on an artificial football surface (FieldTurf FTS01, FieldTurf, Montréal, Canada) approved by FIFA with approach velocity 5.5 m·s<sup>-1</sup> - 6.0 m·s<sup>-1</sup>. Each subject was tested using 2 plastic studded football boots (Adidas Copa Mundial and Nike Air Zoom Total 90 v3 FG) and 2 plastic bladed boots (Adidas Predator Pulse FG and Nike Mercurial Vapor v2 FG), all specified by their respective manufacturers for use on the surface. They performed each manoeuvre in their own consistent style as used during play and commenced by performing two trial runs. The subjects were required to rest at least 2 minutes between each trial to prevent effects of fatigue. Testing was completed for each player in a single session without any changes to the protocol or equipment. Data was collected using an eight camera gait analysis system (120Hz VICON 612, Vicon Motion Systems Limited, Oxford, U.K) synchronised with a force platform (Kistler 9287BA, 960Hz, Kistler, Alton, U.K) which

provided inputs for three-dimensional inverse dynamics analyses. Individual net dominant knee internal/external rotation moments normalised for body mass were determined throughout the stance phase using a 12 parameter direct linear transformation algorithm embedded in to the VICON software. Approach velocity was measured using two pairs of infrared velocity timing gates (Elektio Sport, AB, Sweden), placed immediately in front of the force platform and 2 m in front. All trials were interpolated using a cubic spline to 100 data points to facilitate presentation as a percentage of the stance phase. To enable analysis of potential ACL injury mean absolute net internal knee rotation moments values throughout the stance phase were compared with ACL critical limits collected from previous cadaveric studies. A non-parametric ANOVA followed by Friedman's tests were employed to compare changes in mean absolute knee internal/external rotational moments as a function of cutting angle and boot undersurface type. A significant difference was determined by  $p < 0.001$ .

**RESULTS:** Throughout the stance phase of straight line running using the investigated studded [Adidas Copa Mundial (Figure 1) and Nike Air Zoom Total 90 v3 FG (Figure 2)] and bladed [Adidas Predator Pulse FG (Figure 3) and Nike Mercurial Vapor v2 FG (Figure 4)] football boots, absolute internal rotational knee moments were insufficient to cause potential cadaveric ACL injury in cadavers for each investigated player and each boot.

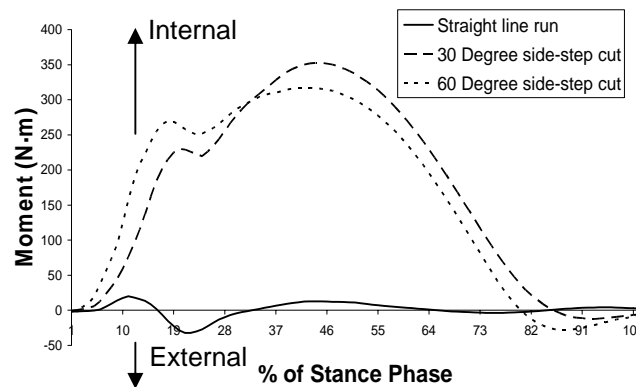


Figure 1 Adidas Copa Mundial mean knee internal/external rotation moments

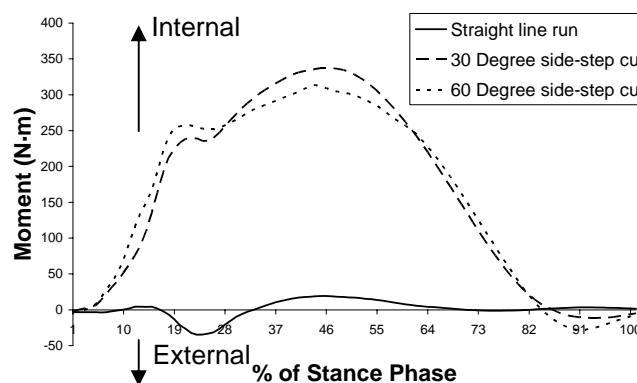


Figure 2 Nike Air Zoom Total 90 v3 FG mean knee internal/external rotation moments

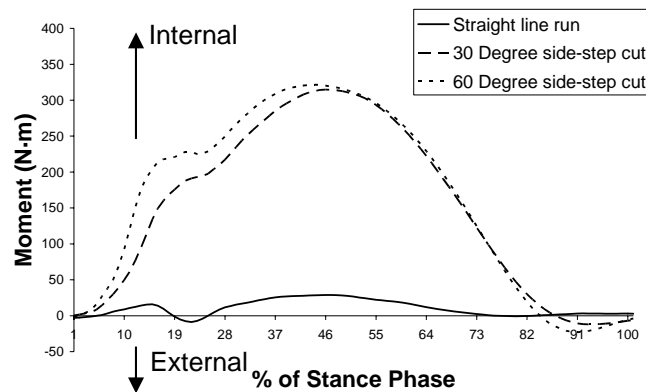


Figure 3 Adidas Pulse FG mean knee internal/external rotation moments

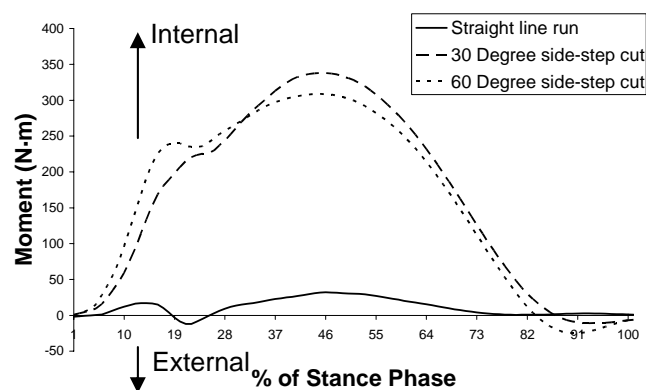


Figure 4 Nike Mercurial Vapor v2 FG mean knee internal/external rotation moments

Seering et al. (1980) identified that ACL damage occurred in cadaveric knee joints above absolute internal rotational moments of 35 Nm - 80 Nm. For each investigated boot, sidestep cutting at 30° and 60° produced mean internal rotational knee moments sufficient to cause ACL injury between 8%-80% of the stance phase, and the greatest risk for injury during the mid-point of the stance phase. Values exceeded critical limits during the stance phase of each sidestep cutting trial for each investigated player and each boot. For each of the boots, internal rotational knee moments during 30° and 60° sidestep cutting manoeuvres were not statistically different. Significantly greater internal rotational knee moments occurred when comparing 30° sidestep cutting manoeuvres to straight line running ( $p < 0.001$ ) and 60° sidestep cutting manoeuvres to straight line running ( $p < 0.001$ ). During 30° sidestep cutting manoeuvres the studded boots were associated with significantly different rotational knee moments when compared between themselves ( $z = -5.835$ ,  $p < 0.001$ ) and the bladed boots were also associated with significantly different rotational knee moments when compared between themselves ( $z = -8.511$ ,  $p < 0.001$ ). For 60° sidestep cutting manoeuvres, the studded boots were associated with similar rotational knee moments when compared between themselves ( $z = -3.403$ ,  $p = 0.001$ ) and the bladed boots were also associated with similar rotational knee moments ( $z = -3.437$ ,  $p = 0.001$ ).

**DISCUSSION:** Mean absolute internal rotational moments detected during 60° and 30° sidestep cutting were significantly ( $p < 0.001$ ) greater than for straight line running as has been detected previously by Besier et al. (2001a) using inverse dynamics analyses. Besier et al. (2001a) detected internal rotation moments during sidestep cutting that were up to 5 times greater than during straight line running. The current research detected peak mean absolute internal rotation moments, which ranged from 315 N·m to 350 N·m, and up to 11 times greater than values during straight line running. This discrepancy is likely a consequence of

investigating subjects using football footwear on an approved football surface and a greater approach velocity. The large mean absolute internal rotation moments detected in this research corresponds with previous work that has identified internal tibial rotation during sidestep cutting is likely to play a major aetiological role in ACL injury (14). Research conducted by Besier et al. (2001) and McLean et al. (1998) using three-dimensional inverse dynamics analyses has highlighted biomechanical changes during side-step cutting manoeuvres are likely to be involved in the aetiology of ACL injuries. This current research has enhanced our understanding of the football boot undersurface and sidestep cutting manoeuvre by utilising an approach valid for match play situations. The majority of the stance phase provided potential for injury. Findings from this research imply that bladed and studded football boots may impart a significantly greater risk for potential non-contact ACL injury during sidestep cutting compared to straight line running. Boots with the same undersurface type for 60° sidestep cutting manoeuvres resulted in similar internal/external rotational moments. However, for 30° sidestep cutting manoeuvres boots with the same types of undersurface were associated with significantly different internal/external rotational moments, indicating the influence on potential ACL injury may not be solely dependant on the undersurface type.

**CONCLUSION:** Internal rotational knee moments during straight line running on a FIFA approved surface using studded and bladed boots were insufficient for potential ACL injury. During sidestep cutting these boots imparted significantly greater internal rotational moments ( $p < 0.001$ ) capable of potential injury. The designs of modern football boot undersurfaces and cutting manoeuvres may be implicated in the high incidence of non-contact football ACL injuries.

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