XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

JOINT LOADING DIFFERENCES BETWEEN NEWLY INSTALLED AND WORN ARTIFICIAL TURF DURING A CUTTING MOVEMENT

Nicole M. Schrier, John W. Wannop, Jay T. Worobets and Darren J. Stefanyshyn
Human Performance Lab, University of Calgary, Calgary, Canada
Email: nschrier@kin.ucalgary.ca

INTRODUCTION

Early versions of artificial turf surfaces were believed to increase the risk of non-contact injury due to increased hardness and footwear traction compared to natural turf [1,2,3]. In recent years, newly developed artificial turf has incorporated infill composed of sand and rubber in addition to an underlying shock pad in attempts to more closely simulate mechanical aspects of natural turf [4]. These additions to the artificial turf system appear to have had a positive influence on injury risk: studies have reported no significant differences in injury rates between newer generation artificial turf and natural grass [5,6].

One aspect of infilled artificial turf which may still have an influence on injury risk is wear. As infilled turf is played upon, the infill can become compressed over time, decreasing the compliance of the turf. Manufacturer's specifications indicate that while newly installed artificial turf should have an impact attenuation near 90 g's (as measured with a Clegg Hammer), the impact attenuation of the surface is expected to decrease over time to approximately 180 g's. The purpose of this study was therefore to compare the effects of newly installed versus worn artificial turf on ankle and knee joint loading during a typical athletic cutting maneuver.

METHODS

Mondo Worldwide Ecofill Pro Series 3NX FTS artificial turf was installed in the laboratory according to manufacturer's specifications. This professional grade turf was composed of a 23 mm underlying shock pad, with a fiber length of 45 mm. The turf contained a base layer of sand infill followed by a layer of Ecofill rubber infill. The dimensions of the turf installed in the laboratory were 7.5 m x 5 m to allow athletes to have enough space to perform a maximal effort v-cut without exiting the turf. A separate section of infilled turf was installed inside a metal box (0.6 m x 0.9 m) that was bolted to a force platform to allow for force measurements during the movement (Figure 1). After installation, a Clegg Impact Hammer [7] was used to verify that the impact attenuation of the newly installed turf was near the manufacturer's specification of 90 g's. The turf was tested in different locations and had an average impact value of 94 g's.

Eleven male soccer players each performed 5 trials of a maximal effort 90º v-cut movement while wearing adidas f50 AG soccer cleats. The subjects commenced by running at a 45º angle relative to the force platform, then planted their left foot in the center of the force platform and cut towards their right at a 45º angle (Figure 1). Spherical retro-reflective markers were adhered to the subjects left shank and shoe for kinematic data collection. In order to define the knee and ankle joint centers, a standing neutral trial was collected with markers placed on the medial and lateral epicondyles (knee) and medial and lateral malleolus (ankle). Kinetic and kinematic data were collected using a Kistler force platform operating at 2400 Hz and an 8-camera Motion Analysis system operating at 240 Hz. The data were imported into KinTrak 7.0.25 for analysis. Internal resultant joint moments were calculated using an inverse dynamics approach.

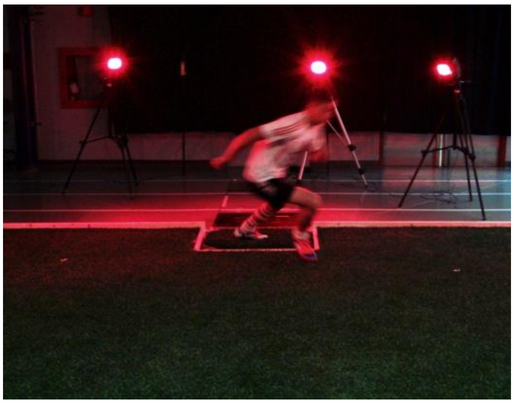

Figure 1: A subject performing the v-cut maneuver on the artificial turf in the laboratory.

After data on each of the eleven subjects were collected, a mobile vibrating platform was used to compact the artificial turf until the impact attenuation of the surface was on average 170 g's: a value purportedly typical of worn but playable artificial turf surfaces. The same eleven subjects then returned to the laboratory and the data collection procedure was repeated.

One-tailed paired t-tests with a significance level of $\alpha=0.05$ were used to identify statistically significant differences between the newly installed and worn turf conditions. The variables of interest were the peak frontal and transverse plane ankle and knee joint moments.

RESULTS AND DISCUSSION

The average ankle and knee joint moment values are shown in Table 1. Decreasing the impact attenuation of the artificial turf from 94 g's to 170 g's had no effect on ankle external rotation or eversion peak moments, nor on peak knee external rotation moments. However, the peak knee adduction moments were statistically significantly higher ($p < 0.01$) on the worn turf compared to the new turf. On average, the worn turf caused a 38% increase in these peak frontal plane moments experienced by the knee during the cutting movement.

Previous studies have linked frontal plane knee joint loading to injury risk [8,9]. Therefore, as an artificial turf surface is compacted over time due to use, a resulting decrease in impact attenuation may increase the players' risk of non-contact knee injury. The results of this study draw attention to the fact that the condition of the artificial turf surface that athletes perform on may have an influence on injury rates.

CONCLUSIONS

The mechanical properties of an infilled artificial turf surface can change as the surface is played upon over the course of years. These changes may have implications for injury risk. This study found that decreasing an infilled artificial turf's impact attenuation from 94 g's to 170 g's resulted in a 38% increase in peak frontal plane knee joint moments experienced during a typical athletic movement.

REFERENCES

1. Bowers Jr KD, Martin RB, *Medicine and Science in Sports*, **8**:81-83, 1976.
2. Adkison JW et al., *Clinical Orthopaedics & Related Research*, **99**:131:136, 1974.
3. Alles WF et al., *Journal of Orthopaedic and Sports Physical Therapy*, **1**:103-108, 1979.
4. Dragoo JL, Braun HJ, *Sports Med.*, **40**:981-990, 2010.
5. Fuller CW et al., *Br. J. Sports Med.*, **41**:i20-i26, 2007.
6. Fuller CW et al., *Br. J. Sports Med.*, **41**:i27:i32, 2007.
7. Clegg B. *Australian Road Res. Bur. Proc*., **8**:1-6, 1976.
8. Stefanyshyn DJ et al., *Am. J. Sports Med.*, **34**:1844-1851, 2006.
9. Wannop JW et al., *Am J. Sports Med*., **38**: 1221-1228, 2010.

Table 1: Average values and statistical results for the joint moment variables.

Parameter	New Turf	Worn Turf	Difference
Ankle External Rotation (Nm)	90	87	---
Ankle Eversion (Nm)	116	115	---
Knee External Rotation (Nm)	55	55	---
Knee Adduction (Nm)	119	164	38%, p<0.01