A Comparison of the Movement Patterns of Specific Rugby Union Movements on Both Natural Turf and Artificial Turf

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1 INTRODUCTION

A limitation of sports kinematic studies is that they cannot fully represent in-situ play conditions for fast dynamic sports. This paper describes the use of new inertial sensor measurement technology (O'Donovan et al., 2009) to analyse player motions in the field under game-like conditions in order to quantify the impact of different playing surfaces on movement patterns. The wireless sensor system used in this study (Shimmer 3, Shimmer Research, Ireland) is a lightweight (50x25x12.5mm^3), wearable, low-power consumption inertial measurement unit that contains a tri-axial accelerometer, gyroscope, and magnetometer. Sensor data can be used to derive a range of spatiotemporal and kinematic variables to quantify performance during gait and other functional activities. In our research we are using these sensors as a means to characterise movement during a running activity. The motivation for this study has been to compare movement profiles and strategies of rugby players performing game related tasks on natural turf surfaces and on synthetic surfaces, to enable a better understanding of the impact of different playing surfaces on movement and associated forces and stresses exerted on the body. This is important as there is a growing trend towards use of synthetic surfaces in rugby union and there have been anecdotal reports of injuries that are perceived to be related to the playing surface. In this paper we present preliminary movement data acquired from players performing a 10m sprint test on natural and synthetic surfaces and describe our methods of data extraction and subsequent data processing.

2 METHODS

Twenty elite rugby union players participated voluntarily. Data were captured from the participants while they performed running trials on both natural and synthetic turf playing surfaces. The specific test carried out was a 10m sprint, which is a standard test used for quantifying linear acceleration in rugby union (Duthie et al, 2006). Sensors placed on the thigh, shank and foot provided data from foot-strike events for subsequent analysis. All post processing and analysis was carried out using MATLAB. Accelerometer and gyroscopic data were calibrated using 9-DOF calibration Shimmer software and were low-pass filtered with a zero-phase 5th order Butterworth filter with 50 Hz and 20 Hz corner frequencies. Acceleration and angular velocity vectors were derived with respect to each segment's coordinate axes. In this paper, we limit our scope to consideration of the process of data extraction and analysis for the data relating to the 10m sprint. Using the gyroscopic data, the parameters of sprinting (foot-strike points) from each motion were successfully identified using the method described by McGrath et al. (2012), where the stride time is given as the time between two successive foot-strikes. These characteristic points successfully allowed stride time, *ST*, to be calculated by:

$$ST(k) = FS(k+1) - FS(k) \qquad (1)$$

where *k* is the number of cycles, and *FS* is foot-strike.

3 RESULTS

A typical sample of the angular velocity data about the sagittal plane that was measured at the left foot

during the 10m sprint in trials on both artificial turf and natural turf is shown below in Figure 1. Figure 2 shows the corresponding resultant of linear accelerations.
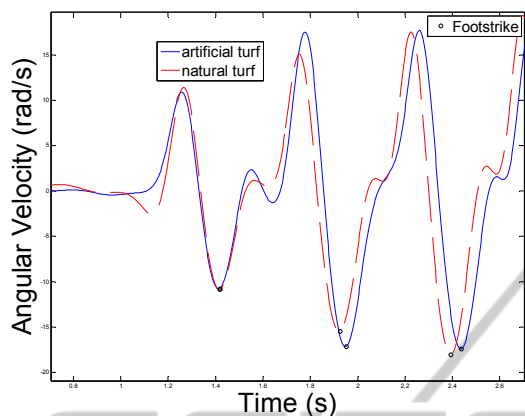

Figure 1: Angular velocity at the left foot about the sagittal plane during the 10m sprint.
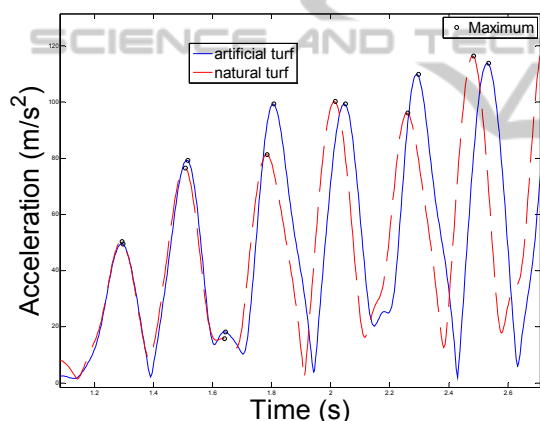

Figure 2: Resultant linear acceleration at the left foot during the 10m sprint.

From the resultant acceleration data demonstrated in Figure 2, it can be noted that accelerations experienced in the first full stride are quite different to the accelerations experienced in the second full stride. The first three maxima of resultant linear accelerations increase significantly with each progressive maximum. The magnitude of the second three maxima seems to plateau at around 110 m/s^2. This shows that during the first stride the participant is accelerating while during the second stride the participant is starting to come to steady state and run at maximum velocity. Taking this into account the results from the first 'acceleration stride' can usefully be presented in tabular format separately from the second stride in which the participants approach steady state.

Table 1: Means, standard deviations and percentage differences of stride times measured at the left foot and collected on both artificial and natural turf while doing the 10m sprint. Values are expressed as mean±SD.

Stride	Artificial Turf (s)	Natural Turf (s)	Percentage Difference (%)
1	0.485 ± 0.046	0.478 ± 0.034	1.355 ± 5.36
2	0.458 ± 0.035	0.458 ± 0.035	0.15 ± 3.16

In Table 1, Stride 1 refers to the acceleration stride while Stride 2 refers to the stride that approaches steady state. The stride times are given in seconds. The percentage difference is the difference between corresponding stride times measured on both surfaces, expressed as a percentage of the stride time measured on natural turf. The difference between the corresponding stride times on both surfaces is shown to be insignificant as the application of a paired T test for means generated P values that were greater than 0.05 (for Stride 1, P = 0.33; for Stride 2, P = 0.9)

In Table 2 Maximum 1 refers to the first maximum of the resultant linear acceleration recorded during the course of the 10m sprint. In total, 6 maxima of resultant linear accelerations were recorded during the course of the test. The percentage difference is the difference between corresponding maxima of resultant accelerations measured on both surfaces, expressed as a percentage of the maximum measured on natural turf. The difference between the corresponding maxima of resultant linear acceleration measured on both surfaces is deemed insignificant since application of a paired T test for means generated P values for all six maxima that were also greater than 0.05 (Maximum 1: P = 0.577, Maximum 2: P = 0.054, Maximum 3: P = 0.35, Maximum 4: P = 0.062, Maximum 5: P = 0.44, Maximum 6: P = 0.2).

Table 2: Means, standard deviations and percentage differences of maxima of resultant linear accelerations times measured at the left foot and collected on both artificial and natural turf while doing the 10m sprint. Values are expressed as mean±SD.

Maximum	Artificial Turf (m/s^2)	Natural Turf (m/s^2)	Percentage Difference (%)
1	55.62 ± 6.48	54.68 ± 9.89	5.25 ± 24.03
2	89.61 ± 8.48	85.8 ± 10.68	5.15 ± 8.9
3	83.85 ± 11	80.65 ± 18.69	14.68 ± 53 .66
4	115.4 ± 10.2	108.36 ± 13.71	8.09 ± 16.25
5	99.31 ± 9.65	101.47 ± 12.02	-1.34 ± 10.26
6	126.6 ± 10.3	122 ± 14.499	4.94 ± 12.7

4 DISCUSSION

On observation of the data, different participants appeared to display slightly different strategies to each other when carrying out the test, but the same participants displayed the same strategy on different surfaces. This enables a comparison of one surface to another. The local minima identified in the angular velocity about the sagittal plane (Figure 1) indicate points of initial contact or foot strike (FS). Analysis of this data for all the test participants showed that each participant completed three clearly identifiable foot strikes during the 10m sprint. Equation (1) shows that each participant completed two full strides in the test. Overall the difference between stride times on both surfaces was very small, which was as expected. The largest average difference between stride times that was measured was 0.0076 s at the left thigh.

The resultant acceleration data for the 10m sprint was analysed by comparing the magnitudes of the corresponding maxima measured on both surfaces. In general, the difference between the maximum points of resultant acceleration measured on artificial turf and natural was not large: the largest average difference was $4.5 m/s^2$ for the third maximum point recorded at the left foot.

5 CONCLUSIONS

From the results presented, it has been shown that there is an insignificant difference between the angular velocity data and the resultant linear acceleration data collected on both surfaces. This would indicate that there is no significant difference in the movement pattern when carrying out a 10m sprint on artificial turf and on natural turf.

6 FUTURE WORK

It is intended to carry out tests that incorporate braking and change of direction in order to identify events of interest associated with these movements.

ACKNOWLEDGEMENTS

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