THE BIOMECHANICAL ASSESSMENT OF TENNIS SURFACE CUSHIONING PROPERTIES DURING A TENNIS-SPECIFIC MOVEMENT

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INTRODUCTION

Nigg and Yeadon (1987) suggested that increased use of artificial surfaces in sports has led to a higher prevalence of overuse injuries. Typical assumptions include an association between excessive peak impact force values and overuse injury. Previous assessments of changes in biomechanical variables during running across surfaces have revealed maintenance of impact peak magnitudes (Nigg and Yeadon, 1987) some of which have been explained by kinematic adjustment including increased initial knee flexion, reduced heel impact velocity on stiffer surfaces and reduced initial foot angle relative to horizontal (Bobbert, Yeadon and Nigg, 1992). Dixon, Collop and Batt, (2000) highlighted the variety of kinematic responses available that could explain maintenance of impact peaks on an individual basis. In relation to tennis, Dixon, Batt and Collop (1999) concluded that the relative level of impact absorption (cushioning) afforded by tennis surfaces was not well understood. It is suggested that employment of a tennis-specific movement may yield trends in force variables and human kinematics to changes in surface that have not been observed during running. The purpose of the present study was to biomechanically assess the relative levels of surface impact absorption while subjects performed a tennis specific movement in the laboratory.

METHOD

The footplant of a tennis running forehand was selected for analysis. Six subjects (670N ±122.2), informed of the desired movement, performed at least 5 familiarisation trials per condition. Eight trials were then collected for each of three different surfaces: artificial turf, carpet and cushioned acrylic hard-court) and a 'baseline' condition incorporating a concrete run-way and an uncovered force plate. The additional three surfaces were laid over the baseline surface during testing. A consistent model of tennis shoe (Adidas Big Court II) was worn by each subject. Subjects were timed using photocells over a short distance during entry into the testing area as an initial measure of trial reliability. Individually selected speeds of entry were permitted. Simultaneous collection of force plate data (AMTI, 960Hz) and kinematic data (Peak Motus) for the foot plant terminating a 9m sub-maximal run was undertaken. Peak impact force, peak rate of loading, initial foot and knee angles and heel impact velocity were analysed. Group mean results were inserted into a repeated measures ANOVA to detect differences in test variables.

RESULTS AND DISCUSSION

Group mean bodyweight-normalised (BW) vertical force data revealed that the baseline surface yielded the lowest peak impact magnitude (Table 1). Statistical analysis revealed that the increase in peak impact force for the tennis surfaces compared with the baseline were significant ($p<0.05$). In support of the group finding, the baseline condition also yielded the lowest peak impact value for each individual subject. This factor alone could indicate that the baseline interface has a high level of cushioning, however mechanical impact testing would suggest otherwise. Group peak rate of loading did not reveal significant differences between surfaces, although individual rates of loading show a trend between surfaces to mimic individual peak impact trends.Explanation of the group peak impact finding for the baseline condition cannot be provided from changes in kinematic variables (Table 1), since no significant differences in kinematic variables were detected ($p<0.05$). It is therefore suggested that individual subject analysis is required to investigate the observed increase in force on tennis surfaces compared with the baseline surface.

Table 1. Group mean results (*$p<0.05$)

	Baseline	Carpet	Acrylic	Artificial Turf
Mean peak impact force (BW)	2.76 (±0.53)	*3.20 (±0.51)	*3.10 (±0.43)	*3.14 (±0.56)
Mean peak loading rate ($BW.s^{-1}$)	360.89 (±209.04)	477.81 (±230.00)	455.70 (±177.35)	507.05 (±291.46)
Mean initial foot angle (degs)	38.36 (±6.34)	36.16 (±9.94)	39.56 (±10.15)	35.57 (±10.19)
Mean initial knee flexion angle (degs)	11.87 (±5.57)	7.49 (±4.92)	11.80 (±7.26)	13.16 (±9.30)
Mean heel impact velocity ($m.s^{-1}$)	2.37 (±0.24)	2.51 (±0.37)	2.5 (±0.41)	2.57 (±0.50)

SUMMARY

It has been found that three different tennis-playing surfaces have resulted in a greater peak impact force during a tennis specific movement than that obtained for a baseline concrete surface. Since this result cannot be explained using analysis of group kinematic data, it is suggested that individual subject analysis is required. Additional kinematic variable analysis may reveal further patterns of either individual response or explanation for the baseline condition yielding the lowest peak impact magnitude.

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