ANALYSIS OF GROUND REACTION FORCES PRODUCED IN BASKETBALL MANEUVERS OVER A SEASON

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The purpose of this study was to determine differences in ground reaction forces of college basketball players over a season. Eleven male Division III basketball players performed eight directional basketball maneuvers in random order on an AMTI© 1000 force plate. Subjects were tested every two weeks over an eight week period. Typical ground reaction force curves for vertical, medial/lateral and anterior/posterior were obtained. Results indicated no significant changes occurred across the group, however individual changes were apparent for some subjects, predominantly in the shuffle movements. This study concluded that there were no significant differences across subjects but individual differences in ground reaction force data did occur in some subjects.

KEY WORDS: basketball, ground reaction forces, durability of shoes

INTRODUCTION: Acute and chronic injuries to the lower extremity are the most common injury in college basketball (Payne et al., 1997). Force production in the lower extremity during typical basketball maneuvers, including sprinting, cutting and shuffling movements, contributes to acute and chronic injuries. Ground reaction forces (GRF) for typical basketball maneuvers have been measured at more than nine times body weight (McClay et al., 1994). Basketball shoes are designed to minimize impact forces and avoid loading to reduce the incidence of injury (Nigg & Segesser, 1992).

The high force production in basketball has implications for development of footwear, which assists in force absorption during high impact activities (Nigg & Segesser, 1992, De Wit et al. 1995). Cushioning is important in absorbing impact forces and reducing overuse injuries (Nike Sport Research Review: Cushioning, 1988), however excessive cushioning can also cause injury due to instability (Robbins & Waked, 1997). The balance between adequate shock absorption and stability is documented in new running shoes of varying midsole stiffness (Dufek & Bates, 1991; Nigg et al., 1987), however little research has been focused on the breakdown of court shoes over a season. The purpose of this study was to record the changes in ground reaction forces due to deterioration of basketball shoes over a season.

METHOD: This study was approved by the University of Puget Sound Institutional Review Board. Experimental procedures were explained to 11 apparently healthy male collegiate varsity basketball players (Height: 1.89 m, Weight: 85.97 kg) and written informed consent was obtained.

Peak GRF, time to peak, and total time of force were analyzed in the vertical (V), anterior/posterior (AP), and medial/lateral (ML) directions. An AMTI 1000 force plate in a very stable 1st floor environment with little to no noise was used at a gain of 2000 Hz to collect ground reaction forces. Typical force drawings for shoes that did not show structural damage and those shoes that were damaged were also reported.

Participants completed a warm-up consisting of a five minute cycle ergometer with low resistance and light stretching. After the warm-up was completed the subjects performed eight different movements on the

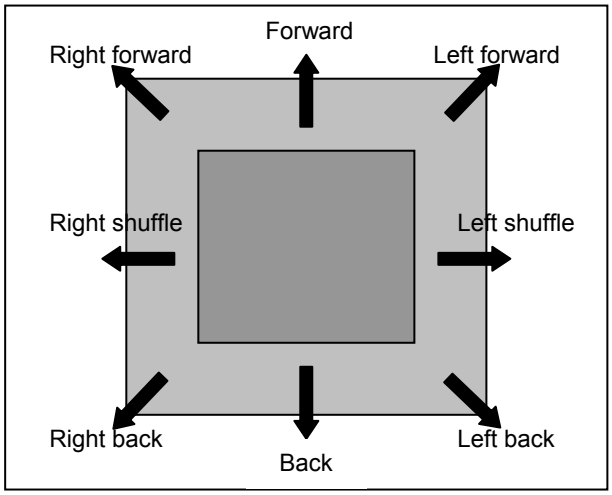

Figure 1. Force plate with eight movement directions

force plate. The eight directional movements included: a forward sprint, a plant and backward movement, as well as right and left forward cutting, side shuffle, and back diagonal motions (Figure 1). The subjects reported to the lab on four separate occasions in an eight week period to perform the same protocol in a randomly assigned order. A one-way repeated measure analysis of variance (1x4) was used to determine significance in each of the variables ($\alpha < .05$).

RESULTS: A significant change did not occur in any of the eight movements over the four trials. Vertical (Table 1), medial/lateral (Table 2), and anterior/posterior (Table 3) peaks, time to peaks and total time showed no significant differences. Individual analysis of ground reaction force data showed changes in some subjects. Changes in peaks, time to peaks and total time were apparent in the shuffle movement of some subjects (Figure 2).

Table 1. Mean (SD) in BW units of vertical ground reaction peak forces and total time

Movement	**Peak 1 Mean (±SD)**				**Mid-Stance Mean (±SD)**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Forward (F)	2.44 (.16)	2.49 (.22)	2.49 (.23)	2.50 (.15)				
Right Cut (FC)	2.21 (.22)	2.38 (.29)	2.41 (.30)	2.35 (.22)				
Right Shuffle (RS)	1.67 (.27)	1.98 (.66)	1.70 (.14)	1.86 (.40)	1.27 (.18)	1.49 (.73)	1.34 (.19)	1.30 (.19)
Right Back (RB)	1.65 (.19)	1.70 (.21)	1.65 (.28)	1.73 (.39)	39.1 (11.7)	37.8 (6.0)	46.4 (15.4)	39.9 (15.3)
Back Pedal (B)	1.45 (.19)	1.64 (.32)	1.55 (0.27)	1.66 (.33)	1.12 (.18)	1.23 (.34)	1.24 (.24)	1.21 (.28)

Movement	**Peak 2 Mean (±SD)**				**Total Time Mean (±SD)**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Forward (F)					125.2 (15.7)	124.3 (14.6)	125.0 (13.6)	127.4 (10.5)
Right Cut (FC)					161.5 (18.7)	145.9 (14.1)	149.5 (17.3)	158.4 (16.3)
Right Shuffle (RS)	1.48 (.15)	1.75 (.66)	1.56 (.14)	1.54 (.19)	258.50 (25.9)	239.90 (27.9)	238.80 (23.2)	255.22 (23.2)
Right Back (RB)	1.48 (.14)	1.47 (.16)	1.43 (.17)	1.42 (.08)	311.4 (65.5)	315.9 (37.7)	291.9 (58.2)	297.8 (80.4)
Back Pedal (B)	1.45 (.12)	1.45 (.17)	1.45 (.19)	1.44 (.16)	277.5 (77.2)	304.0 (78.1)	282.4 (54.9)	287.8 (78.0)

Table 2. Mean (SD) of medial-lateral ground reaction peak forces in BW units

Action	Peak 1 Mean (±SD)				Mid-Stance Mean (±SD)				Peak 2 Mean (±SD)			
	1	2	3	4	1	2	3	4	1	2	3	4
F	0.93 (.07)	.16 (.14)	.08 (.09)	0.07 (.07)								
RC	.63 (.42)	.71 (.38)	.70 (.35)	.68 (.34)								
RS	.53 (.12)	.66 (.16)	.6 (.12)	.61 (.17)	.44 (.10)	.52 (.15)	.50 (.14)	53 (.17)	.70 (.12)	.80 (.12)	.73 (.13)	.76 (.09)
RB	.25 (.12)	.25 (.16)	.35 (.18)	30 (.18)	.16 (.12)	.14 (.09)	.20 (.16)	.19 (.15)	.41 (.12)	.40 (.06)	.43 (.10)	.40 (.05)

Table 3. Mean (SD) of anterior-posterior ground reaction peak forces in BW units

Movement	Peak 1 Mean (±SD)				Peak 2 Mean (±SD)			
	1	2	3	4	1	2	3	4
F	-.32 (.16)	-.34 (.13)	-.28 (.13)	-.32 (.11)	34 (.10)	.35 (.12)	.34 (.09)	.33 (.09)
RC	-.64 (.21)	-.66 (.09)	-.62 (.17)	-.70 (.17)	20 (.06)	.21 (.07)	.21 (.07)	.18 (.06)
RS	-.82 (.16)	-.79 (.17)	-.84 (.12)	-.85 (.12)				
RB	-.90 (.08)	-.89 (.08)	-.89 (.07)	-.87 (.08)				
B	-.89 (.08)	-.86 (.11)	-.87 (.09)	-.91 (.09)				

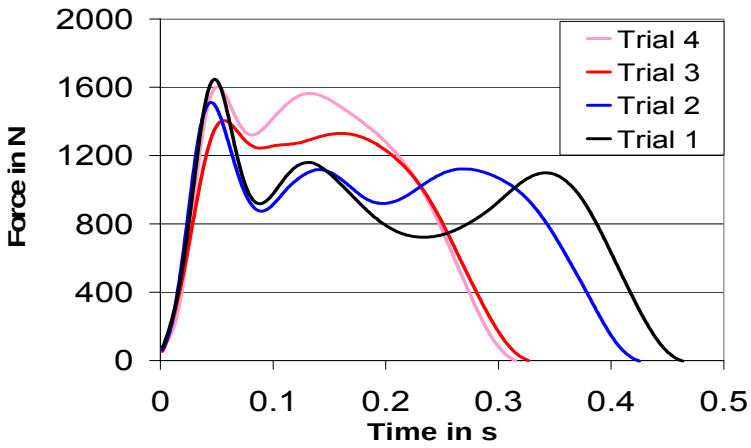

Figure 2. Typical vertical forces for Right Shuffle with changes between trials

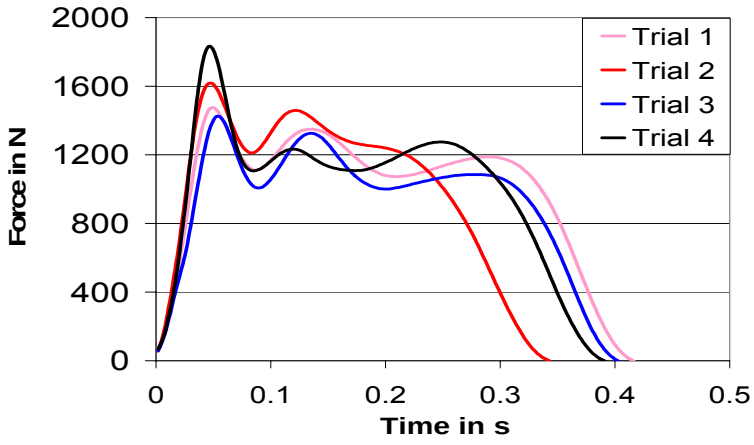

Figure 3. Typical vertical forces for Right Shuffle with no change

DISCUSSION: Typical kinematic patterns of vertical, anterior/posterior and medial/lateral ground reaction force curves for basketball maneuvers have been established in previous literature (McClay et al., 1994) and were similar to the initial curves found in this study It is not evident from past literature whether these variables change as a result of shoe deterioration. This study intended to establish group differences between typical ground reaction force data with new shoes and shoes after eight weeks of wear.

Analysis of group data showed there were no significant differences between the four trials in any of the eight movements. However, differences in individual responses to the same

stimuli can compromise group results (Bates & Stergiou, 1996). Individual differences in ground reaction force data were not apparent in all subjects, but noticeable changes, possibly indicating shoe wear, were evident in some subjects (Figure 2) The defensive oriented guards seemed to show the most obvious variation between new shoes and shoes after eight weeks of wear. The variation seen in their ground reaction force data could have been a result of shoe wear, while subjects who did not show such changes had not worn out their shoes in the eight week period.

Changes in ground reaction force data did not occur in all eight movements, which might indicate that shoe deterioration effects certain movements more than others. The shuffle movement exhibited the most apparent changes (Figure 2, 3), while subjects showed minimal variation in peak force, time to peak and total time in the forward run and right cut movement. McClay et al., (1994) established three peaks in the vertical force of the shuffle movement, which was replicated in this study. Changes in these forces over the eight week period showed a shift from three to two peaks with a decrease in total time (Figure 2). Not all subjects exhibited this change and might have been a result of minimal shoe deterioration (Figure 3).

CONCLUSION: No significant group differences were found in the analysis of ground reaction force data for the eight movements, however individual differences were apparent in some subjects possibly indicating shoe deterioration.

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