EFFECT OF TYPE 3 BALL ON UPPER EXTREMITY EMG AND ACCELERATION IN THE TENNIS FOREHAND

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The effect of the larger type 3 tennis ball on upper extremity EMG and impact acceleration was studied in a diverse sample of adult tennis players. Twelve players from intermediate to advanced levels of ability played no-add sets of six games using the larger and the regular tennis ball. Racket acceleration and upper arm muscle activation were measured during forehands with a Noraxon telemetry system. Within-subject statistical analysis showed that half of the players had significantly ($p < 0.05$) greater mean normalized-rectified EMG of the biceps or triceps with the larger ball compared to the regular ball. Half of the players with complete acceleration data also had significantly ($p < 0.05$) greater mean rectified acceleration after impact with the larger ball.

KEY WORDS: electromyography, shock, injury

INTRODUCTION: Changes in racket design and construction have increased the speed of tennis play and may have contributed to recent changes in technique and injury patterns (Brody, 1995; Groppel, 1995). One of the most recent changes in the game is a two year experimental period for the evaluation of a larger (6% in diameter but same mass) type 3 tennis ball approved by the ITF (Havelak, 1999). While the flight of the larger ball is predictable based on the laws of physics (Brody, 1987; Haake et al. 2000), it is unclear how the larger ball will affect the biomechanical responses of players. To date, the only studies of the larger type 3 ball have focused on simulated impacts (Goodwill & Haake, 2000), match play statistics, grip force, and player perceptions of muscle soreness (Mitchell & Caine, 2000). The purpose of this study was to determine if there are differences in upper extremity muscle activation and impact shock using the larger ball compared to the regular tennis in actual matchplay conditions.

METHODS: A diverse sample of intermediate to advanced adult tennis players gave informed consent to participate in the study. Subjects were ten males and four females from ages 21 to 66 years with National Tennis Rating Program ratings between 3.5 and 6.0. Following a warm-up, subjects played two groups of six games using no-add scoring using either the regular or larger ball. Subjects played against an opponent of equal ability on an indoor tennis court, with the order of play for kind of tennis ball randomized.

A Dytran miniature accelerometer (#5105) was glued above the grip to a midsized tennis racket that was strung with nylon at 60 lbs of tension. A battery powered power supply and Noraxon telemetry transmitter were secured to a belt worn by the players. Racket acceleration, raw and rectified surface electromypgraphic data from the lateral head of triceps and the biceps were transmitted to a receiver, digitized at 1000 Hz, and stored on a computer. As many samples of forehand drives and forehand service returns were collected for each kind of ball during matchplay. The variables of interest were the mean rectified acceleration for the 100 ms after impact (Hennig et al. 1992) and the mean smoothed rectified EMG burst prior to impact normalized to mean smoothed rectified EMG in maximal isometric voluntary contractions (NEMG). The data were compiled and summarized with descriptive statistics and comparisons of ball type were made for each subject using 95% confidence intervals (Sim & Reid, 1999). Data are reported as mean (sd).

RESULTS: A male and female subject withdrew from the experiment because of an unrelated injury and a time constraint. Various technical and other constraints limited the availability of complete data for the remaining twelve subjects. Accurate NEMG data were available for ten players and accelerometer data were available for four players for statistical analysis. The mean number of forehands analyzed for each ball type across all subjects was 9.5 (2.8) strokes. Five of ten players had significantly ($p < 0.05$) greater mean NEMG of biceps or triceps using the larger ball compared to the regular ball (Table 1). The effect sizes for the players with differences in muscle activation were large (0.67 to 4.1). When mean NEMG was calculated from both muscles and averaged across subjects, the larger ball had a trend of higher activation 68.4 (17.4)% than the regular ball 61.9 (11.7)% that approached statistical significance (t_9 = 1.83, $p < 0.099$).

Table 1 Normalized EMG Activity in the Forehand (Mean and 95% Confidence Intervals)

	Biceps		Triceps	
	Regular	Big	Regular	Big
	83.3 (71.0 – 95.5)	93.4	29.9 (18.9 - 40.8)	46.6*
	48.1 (40.1 - 56.1)	43.9	47.6 (41.7 – 53.4)	50.4
	51.8 (34.1 – 69.5)	61.1	112.7 (91.1 – 134.4)	117.1
	32.8 (26.5 - 39.2)	34.0	72.5 (54.5 – 90.4)	94.2*
	41.1 (34.5 – 47.6)	39.3	65.1 (56.0 – 73.3)	58.1
	51.3 (37.9 – 64.7)	50.5	60.2 (51.6 – 68.9)	53.1
	69.3 (57.9 – 80.7)	64.4	80.2 (70.3 – 90.1)	75.0
	60.5 (37.2 – 83.9)	79.6	61.2 (54.2 – 68.3)	99.8*
	73.3 (64.9 – 81.8)	65.1	80.8 (69.6 – 91.9)	113.1*
	47.9 (34.8 – 61.0)	63.3*	67.2 (51.6 – 82.8)	56.4
Mean	56.0	59.5	67.8	76.4
sd	15.5	18.3	21.9	27.3

Data are expressed as a percentage of maximal isometric voluntary contraction, and * indicates a significant ($p < 0.05$) difference between the larger type 3 ball and the regular ball for an individual subject based on the 95% confidence intervals in parentheses.

Two of four players had significantly ($p < 0.05$) greater mean rectified acceleration after impact in the larger ball compared to the regular ball. The effect sizes for these differences were also large (0.68 and 1.17). Averaged across the four subjects the mean rectified acceleration (arbitrary units) for the regular and type 3 ball were 1510 (239) and 1668 (129), respectively.

DISCUSSION: The study was effective in the non-invasive measurement of the short-term upper extremity responses of typical adult tennis players to matchplay with the larger type 3 ball. The NEMG and acceleration variables studied showed high levels of variability (coefficients of variation between 18 and 59 percent) which was consistent with previous studies of biomechanical variables in tennis (Knudson, 1990; Knudson 1991a, 1991b; Knudson & White, 1989; Plagenhoef, 1979). The investigators qualitatively noted that the players quickly adjusted their play to the flight and bounce of the larger ball. This was consistent with similar observations of advanced players using the larger ball (Mitchell & Caine, 2000).

There were no trends in the NEMG and accelerometer data related to gender or skill level of the players. Half of the tennis players studied showed significantly greater muscle activation or post-impact acceleration using the larger ball compared to the regular ball. While the players studied represented a wide variety of intermediate to advanced adult tennis players, the sample can not be representative of the whole population of adult players using the larger ball in the wide variety of player, weather, and court conditions. More research is needed to determine the long-term responses of players to using the larger ball. Prospective studies might also begin to determine the levels of muscle activation and acceleration that may be related to greater risk of upper extremity overuse injuries in tennis.

CONCLUSION: The data demonstrated that half of the tennis players studied had significantly larger muscle activation and acceleration after impact in forehands using the larger type 3 tennis ball compared to the regular ball. These differences (17 to 63 percent larger) were about the size of the typical, large variability of biomechanical variables in tennis play. It is not clear if these differences pose a greater risk of overuse injuries in the players who might make these adaptations.

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