THE COMPARISON OF ELBOW ACCELERATION BY WEARING DIFFERENT TENNIS ELBOW BRACES

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The purpose of this study was to analyze the discrepancy of impact between forehand and backhand strike and compare the difference of elbow impact acceleration among various elbow braces. Eight elite tennis players and eight amateur players were served as the subjects to conduct the test of forehand and single backhand strikes. Three accelerometers were used to acquire the acceleration signals. The subject was asked to perform forehand and backhand strikes with 3 brace situations (no brace, aircast brace and counterforce brace). Two-way ANOVA was performed to determine the discrepancy among the tennis players of different skill level with three different brace conditions. When forehand striking, the acceleration signal had significant differences between elite and amateur groups whether wearing brace or not at racket and elbow area. When backhand striking, the acceleration signal had significant difference between elite and amateur groups whether wearing brace or not at racket and elbow area. It seems that the elite players could strike the ball at center of racket (sweet spot) result in the energy transfer return to ball and reduce the vibration of racket. It had no significant difference between three bracing condition. It means that wearing brace can not reduce impact, it only change the pulling direction of the wrist extensor muscle when wrist action.

KEY WORDS: tennis elbow, brace, acceleration

INTRODUCTION: Tennis has become more and more universal recently (Roetere,1995). A variety of tennis equipment and accoutrements for protection are also more delicate and lighter. Tennis is one of the racket-holding sports that the process of playing is not accomplished until the strength is conveyed to the racket with forearm to touch the ball (Anderson,1992). During a normal tennis match, a player can strike the ball over 1000 times. Each strike can produce racket vibration which is caused by the impact between the ball and racket string. After the impact, potential energy is stored by the string, then return it to ball as kinetic energy. Only part of the energy can be transferred to ball's kinetic energy in this impact process, the rest of energy will cause the vibration of the ball, string and racket frame. The vibration of racket frame is absorbed by human arm which are distracting and uncomfortable, and even cause fatigue or injury. Impact on the center of racket face (Sweet spot) can transfer more energy to ball and reduce the frame vibration. If impact position is close the frame, most of the energy will transfer to the racket frame causing vibration, and reduce the return ball speed.（Brody, 1995） Tennis elbow has being a major concern for most of tennis players, but the etiology of tennis elbow is not fully understood (Renströn, 1994). However, according to previous studies, there are many factors that cause of tennis elbow, Hennig et al (1992) pointed out that various factors might increase the likelihood of developing tennis elbow such as age, frequency of play, force, lack of movement accuracy, grip tightness and impact vibration. Recent studies (Shiang, 1997, Roetert et al, 1995) concluded that the energy transfer process of racket and ball impact could transfer part of the energy to the vibration of arm which could induce arm overuse injury. The impact shock and post-impact vibration transfer in tennis have been hypothesized to contribute to upper extremity injuries. Therefore, there are two objectives for this study, first, to analyze the discrepancy of impact between forehand and backhand strike, second, to compare the difference of elbow acceleration among various elbow braces.

METHODS: Eight elite tennis players and eight amateur players were served as the subjects to conduct the test of forehand and single hand backhand strikes. Three accelerometers were used to acquire the acceleration signals. One single-axis accelerometer (range 300 g) was fixed on the center of racket handle, 2 tri-axial accelerometers (range 50 g) were attached on the skin with bony landmarks 3 cm above wrist and elbow joint.(Figure 1) The accelerometer signal was recorded using BioPac system. The sampling time is 10 seconds for each strike and sampling rate is 1000 Hz. The subject was ask to perform forehand and backhand strikes with 3 brace situations (no brace, aircast brace and counterforce brace). Each condition repeated 12 ball-strikings. The ball speed was controlled to be 35 mile/hr by serving machine, and the subject strike the ball back to the target area with ball speed ranging within 50 to 60 mile/hr.(Figure 2) Two-way ANOVA was performed to determine the difference among the tennis players of different skill level with three different bracing conditions. The significance level was set at $p < .05$.

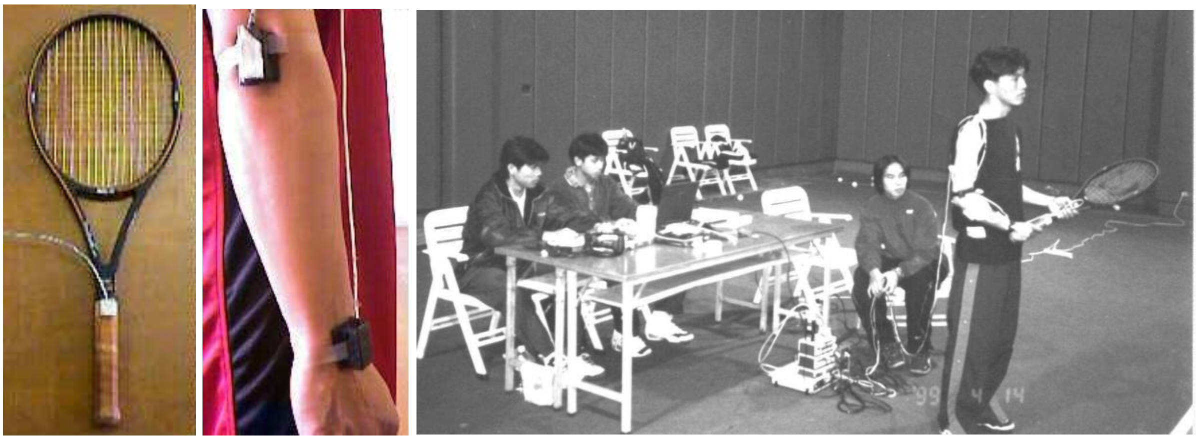

Figure 1 - The attached positions of 3 accelerometers.

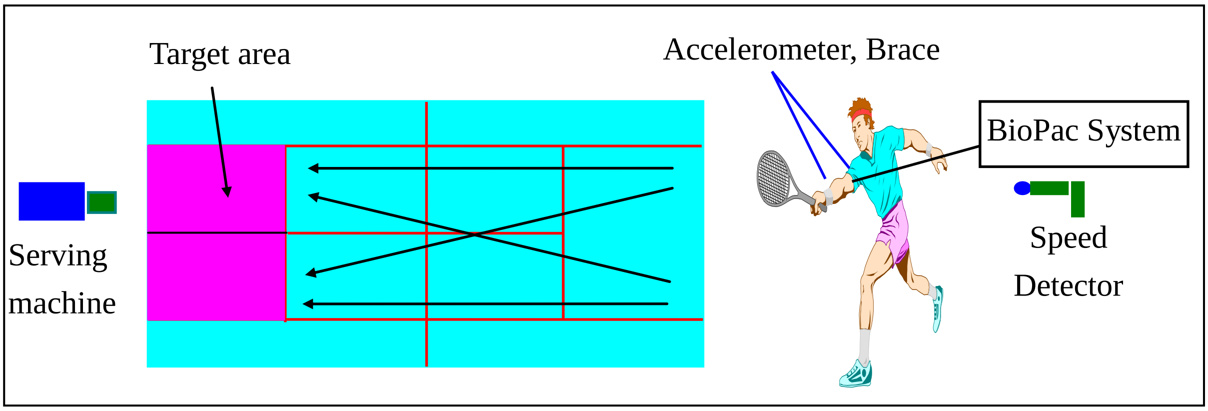

Figure 2: The experimental setup.

RESULTS AND DISCUSSION: The mean and standard deviation of peak acceleration in different location with various brace situation are shown in table 1. The statistical analysis results also display in table 1. When forehand striking, the acceleration signal had no significant differences between elite and amateur groups whether wearing brace or not at racket, wrist and elbow area. When backhand striking, the acceleration signal had significant difference between elite and amateur groups whether wearing brace or not at racket and elbow area. Table 1 also illustrated that the impact deceleration was reduced at wrist compared to elbow. The ratio of wrist and elbow impact deceleration is 1/2. This trend is readily understood since the forearm muscle plays an important role to absorb the vibration energy.
From the result, It seems that the elite players could strike the ball at center of racket (sweet

spot) result in the energy transfer return to ball and reduce the impact of racket. To compare the acceleration of the elbow, the results showed that the elite players used more elbow movement to complete the striking motion, but the amateur players used less elbow movement, so that the elite players had large acceleration signal than amateur players in elbow area. The backhand strike had the same condition as the forehand striking. In this study, It had no significant difference between three bracing conditions. It means that wearing brace can not reduce vibration, it only change the pulling direction of the wrist extensor muscle when wrist action. It would be interesting to see the person with tennis elbow wearing brace in striking movement.

Table 1 The mean and standard deviation (M±SD) of acceleration (g) in different locations with different brace situations

position	brace	group	forehand acceleration (Mean ±S.D.)	backhand acceleration (Mean ±S.D.)
racket	N	E	131.90 ±22.98	119.24 ±14.24*
		A	133.46 ±13.81	131.08 ±14.76
	AC	E	129.85 ±17.39	123.27 ±14.91*
		A	139.95 ±15.96	139.84 ±25.3
	CF	E	136.71 ±18.81	129.17 ±16.65*
		A	144.58 ±29.47	135.23 ±19.46
wrist	N	E	28.28 ±14.92	25.08 ±12.56
		A	31.27 ±8.20	23.60 ±4.01
	AC	E	27.69 ±14.2	24.36 ±9.65
		A	28.76 ±6.40	24.36 ±4.72
	CF	E	28.32 ±13.68	23.37 ±6.67
		A	30.25 ±7.33	22.65 ±3.17
elbow	N	E	12.95 ±6.15	13.08 ±3.89*
		A	12.35 ±2.35	10.62 ±2.11
	AC	E	13.77 ±5.45	13.01 ±4.38*
		A	12.62 ±1.95	10.32 ±2.56
	CF	E	14.22 ±3.91	12.99 ±4.31*
		A	12.14 ±2.55	10.04 ±2.22

Note: N indicate wearing no brace; AC indicate wearing aircast brace; CF indicate wearing counter-force brace; E means elite group, A means amateur group; * represent significant difference ($p < .05$) between E and A groups backhand strikes.

CONCLUSION: The study presented here shows that the elbow can be easily injured in such a high-impact power sport if tennis players can not obtain a good cushioning racket and correct techniques. Because the arm and elbow absorbed repeat impact and vibration energy which can cause over-use injury. The results suggest that increase the muscle of forearm can reduce the elbow injury from vibration. And it also could prevent the injury by striking the ball with appropriate wrist and elbow position. Further attention should be focus on the EMG analysis to thoroughly understand the tennis racket impact effect on the elbow and surrounding tissues.

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