EFFECT OF ATTACHING STRING DAMPERS ON VIBRATION CHARACTERISTICS OF A TENNIS RACKET

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The “damper”, a small device attached to the tennis racket string-bed, is commonly used by tennis players with little scientific support for its functions. The purpose of this study was to clarify the effect of damper attachment on racket vibration characteristics. Two accelerometers attached at different locations were used to measure racket handle and string-bed vibration patterns with and without a damper. Ball-racket impacts were controlled by releasing the ball above the racket for producing consistent impact intensity at four different locations. Although amplitudes of spring-bed acceleration could be reduced by the damper, vibration on the racket handle was not affected by the damper.

KEY WORDS: accelerometer, impact location, racket handle, sport equipment

INTRODUCTION: Tennis is one of the most popular sports activities worldwide. In addition to improvements in athletes’ techniques, there is also incessant development in the equipment. The sport of tennis mainly involves impacts between the ball and the racket. In modern tennis games, advances in racket material and athletes’ strength/technique have increased ball speed and loading in the arms. With higher speeds and shorter time to react, the probability of off-set impacts (impacting out of sweet spots) rises. Moreover, higher ball speeds produce greater vibration amplitudes transmitted to the hand/arm, causing uncomfortable feelings in tennis players and even development of the “tennis elbow” (Hennig, Rosenbaum, & Milani, 1992). Altogether, modern rackets with higher stiffness (Brody, 2000; Haake, Choppin, Allen, & Goodwill, 2007) may be the reason for higher ball speed in modern tennis games, but stiffer racket frames absorb less impulse and energy during impact (Brody, 2000), resulting in greater risk of injury. Consequently, reducing the vibration transmitted to the hand is a key topic in every manufacturer.
Several tennis manufacturers market a small device called the “damper” which has become very popular among tennis players in recent years. Tomosue, Sugiyama, Yoshinari, and Yamamoto (1995) indicated that accelerations of the handle of a racket were decreased by using string dampers. However, Stroede, Noble, and Walker (1999) reported insignificant differences on racket aceleration when dampers were attached. Moreover, they indicated that reducing hand and arm discomfort with the use of dampers was a sensory confusion, and argued that while dampers can decrease string vibration, they cannot absorb a significant amount of frame vibration energy. To clarify the function of attaching dampers, this study used acceleration sensors to measure the vibration of a racket frame and string-bed. The aim of this study was to examine the effect of dampers installed at different locations on the string-bed during offset and central impacts.

METHODS: The Yonex Vcore tour G racket (Tokyo, Japan) and Slazenger the Wimbledon Ball (Shirebrook, UK) were tested. The racket was strung with 16 gauge Wilson Revolve nylon string (Chicago, IL, USA) at 50 lbs. of tension. Since grip conditions were shown to affect racket vibration (Cross, 1998), for better experimental control and reducing the number of variables, the bottom end of the handle was clamped. For consistent impact force and location, free-falling balls were released at 3m above the racket.
The experiment included 4 impact locations (3 center-line and 1 off-centered locations) and 2 damping conditions (with and without a damper). The 3 center-line locations were at the geometric center of the racket face (point C), and 0.08m from the top and bottom of the racket frame, respectively (Fig. 1). The off-centered impact location was 0.07m next to point C.

Two accelerometers (Sadhu Design corp., Hsinchu, Taiwan) installed at different locations (Fig. 2) of the racket with sampling rate 150 kHz analyzed vibration amplitude, frequency and damping rate. Five trials were performed for each impact location/damping condition (with the total of $4 \times 2 \times 5$ trials). Significant differences between different conditions were identified with P < 0.05.

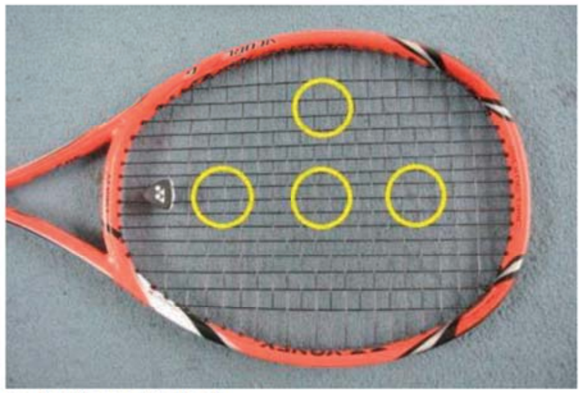
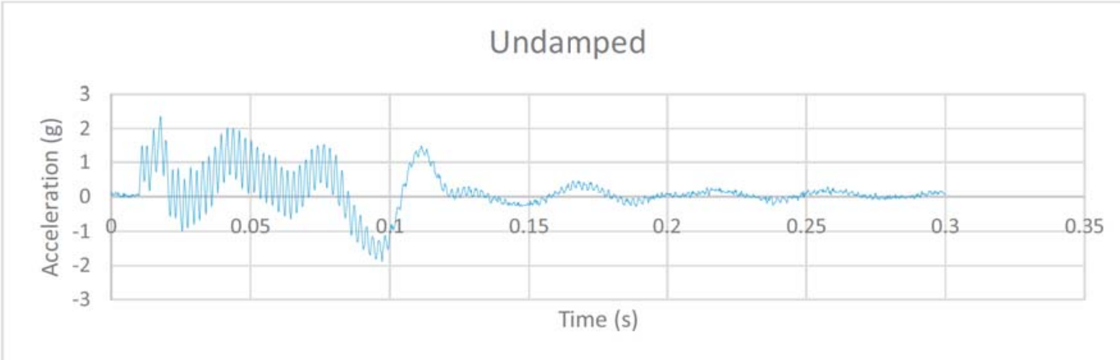


Figure 1: Impact locations (yellow circles).

Figure 2: Location of accelerometers (green rectangles).

RESULTS: To test the effect of damper attachment, the amplitude and frequency of each acceleration profile were analysed. It was found that for the accelerometer located on the spring-bed, the amplitude (of the acceleration data) at initial impact was significantly smaller when the damper was attached (Fig.3). For the accelerometer on the racket handle, attaching the damper caused no difference in either frequency or amplitude of the acceleration profile. High frequency oscillation of the acceleration profile was more prominent for accelerometers located on the spring-bed than on the handle regardless of the attachment of the damper .



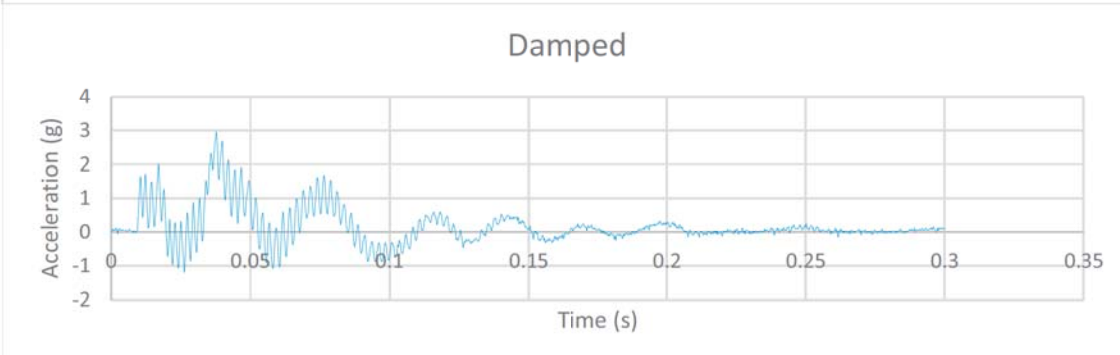


Figure 3: Acceleration data of accelerometer no.1 with/without the damper.

DISCUSSION: This study investigated the effects of string dampers on vibration characterestics of the racket and string-bed by examining acceleration data profiles of acclerometers attached at different locations. It was found that the damper indeed significantly reduce the vibration amplitude of the string-bed, as was claimed by manufacturers. This resulted was also supported by pervious studies (Li, Fewtrell, & Jenkins, 2004; Stroede et al., 1999). However, attaching the damper caused no significant difference in either amplitude or frequency of the acceleration profile on the handle. This might be due to the damper's small mass compared with the mass of a tennis racket, and consequently the effect of absorbing vibration from the racket frame in a small time interval was insignificant (Brody, 1989). Smaller amplitude of high frequency oscillation on the handle than on the spring-bed was identified. This might support the claims that special composite material or dedign added to the racket throat could reduce high frequency oscillation and diminish the vibration transmitted to the handle and forearm.

There are some limitations to this study. In order to have consistent ball speed and impact locations, impacting the racket with free-falling balls was adopted. Also, in order to eliminate the individual difference and clarify the effect of damper, we used clamped handle condition. However, this situation was different from actual condition on the court. Moreover, this study did not consider the effect of spin rate and incidence angles, which may cause differences between the results obtained in the lab and on a tennis court.

CONCLUSION: Although amplitudes of spring-bed acceleration could be reduced by the damper, vibration on the racket handle was not affected by the damper. The effect of reducing vibrations felt by tennis players might therefore be a kind of sensory confusion. Future research can include ball spin rate and incidence angles and even consider attaching more than one damper or attaching different kinds of dampers.

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