THE EFFECT OF TENNIS RACKET STRING VIBRATION ABSORBER PLACEMENT ON TENNIS RACKET VIBRATIONS

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The purpose of this research was to analyze the vibration effect of tennis racket caused by impact on different locative vibration absorber and locations. In this experiment, The tennis racket was fixed and kept the face horizontalized to the ground with 50 lb on strings. A tennis ball was dropped from one meter height to impact three locations of the racket. The different locative vibration absorber was fixed on the racket. It was installed an accelerometer to capture the vibration signal of the handle of the racket. After the experiment, the data was used logarithmic decrement to calculate damping ratio. It was illustrated when the vibration absorber in Back and Tip to have obvious effect. But in Side, it could not effectively decrease the vibration compared with the racket without absorber.

KEY WORDS: tennis, vibration, absorber

INTRODUCTION: The purpose of this research was discussed locations of vibration absorber used to effect of high frequency absorbed. Claire et al. (1999) even used to discuss the effect to decrease high frequency with vibration absorber and without vibration absorber, and impact the different locations by participants grasping the racket. In result, they illustrated the vibration absorber to effectively depress the high frequency of the racket impacted and reduce the hand discomfort. Claire et al. (1997) used the different rackets and 20 participants to research. They used a ball machine to serve a ball that velocity was 21 m/s to impact the COP of the racket and the Tip of the racket to discuss the affection of the vibration absorber to the vibration of the racket. In result, they found the dampers to effectively absorb the high frequency of the racket but did not make the lower frequency decremented. Lin (1997) even used two different type vibration absorber and dropped the ball to the different locations and locations were Side (3, 9 o'clock), Back (6 o'clock), Forward (12 o'clock), the tennis ball were dropped from 2 meters to impact the racket to occur vibration. In result he illustrated the linear damper to have the maximal damping ratio and drop the COP to have the minimal vibration. Brody and Lindsey (2003) even make an experiment to illustrate "The hand is the best damper and there is no evidence that vibrations of the racquet frame or strings are a cause of any sort of arm injury". Cross (2003) even used a piezo sensor attached to the handle near the butt end to measure the shock and vibration of the different rackets. In result, it was found to occur the biggest vibration near the tip or the throat of a racket. Brody (2003) researched the locations of impact vibration occurred to find the lowermost shock or jar to the hand called the center of percussion (called the node or COP), and the ball impact location where the player gets to the maximal power.

The purpose of this research was found any vibration absorber placement used to affect the vibration of the racket. We dropped the ball to different locations and fixed the different locative and quantity vibration absorber to affect logarithmic decrement and found the appropriate locations of the vibration absorber.

METHODS: One Midsized graphite/kevlar tennis racquet (Babolat Pure Drive) weighted 315 grams, balance point at 320 mm was used for this experiment. The racket was had been strung at 222 N (Yonex Tour Super850 Pro 1.32 mm), the material of the string was Nylon Multifilament. The racquet was clamped horizontally to a sturdy wood made framework along the grip of the racquet. One brand new tennis ball (Wilson, Double Core) was fixed by a suction gauge one meter above the racquet, and let the ball drop to impact 3 different location of the racquet face and each location for 10 times, The locations are the tip of the racquet, geometric centre of the racquet head, and the handle of the racquet. An accelerometer have installed on the throat of the racquet to capture the vibration signal of the racket. We then used two different softwares, Bioware and ACQ, to analyze the raw data. In

Table1 and Table 2 was shown the impact locations and locative vibration absorber placement.

Table 1 The ball was dropped on three locations on the racket.

	COP	Tip	Handle
Ball dropped Locations			

Table 2 The locations on the racket the vibration absorber were fixed.

	No	Back	F&B	Side	Four	Elas
Damper Locations						

In the other hand, it was assumed a single degree of freedom system for the racket vibration and used the logarithmic decrement equation to calculate the damping ratio.

The logarithmic decrement and half-width methods were commonly used to calculate the damping ratio in a single degree of freedom system. The logarithmic decrement method may be used to calculate the damping ratio of a single frequency oscillation directly from the acceleration response due to an impact force. The logarithmic decrement method determines the viscous damping ratio from a measured acceleration response and was defined by following equation:

$$\delta = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} = \frac{1}{n}\ln\frac{X_0}{X_n}$$

Where δ was logarithmic decrement, ζ is damping ratio. n was number of cycles used. X_0 was cycle amplitude at time $t = t_0$ and X_n = cycle amplitude at time $t = t_n$ (McCounell,1995).

RESULTS: Constituting vibration absorbers were to reduce high-frequency vibration of racket impacted. Not all of locative vibration absorbers can effectively lower high-frequency vibration. On one hand, based on the outcome of experiments, in racket side didn't be shown any significant effect. Particularly when the ball was dropped on COP of the racket, its effect was lower than a racket without vibration absorber. On the other hand, when the ball was dropped on tip or handle of the racket, it was had a significant impact on high-frequency vibration. Obviously, in the back was also had the same effect. Some professional sportsmen set elastic rub ber on the racket back. Accordingly, in our experiments we did it in the same way to find out how elastic rubber affects high-level vibration. Based on the result of these experiments, elastic rubber could be created relatively high damping ratio as a ball dropped in the COP, Tip and Handle of the racket. All the damping ratio data of the locative vibration absorbers were constituted and impacted locations shown in Figure 1.
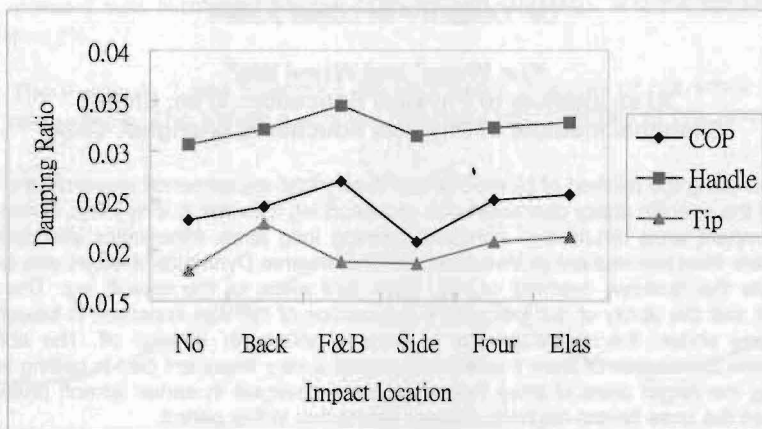
Figure 1   Comparing the damping ratio of the different locative vibration absorbers were fixed and impacted locations of a racket.

DISCUSSION: According to the result, besides setting vibration absorbers on two sides of the rackets, vibration absorbers can also have an significant effect. It was possible that the weight of vibration absorbers could be created a slight impact on the structure of the racket. Particularly an increase of 10g in four vibration absorbers could affect the basic structure of the racket.

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