VIBRATIONAL ANALYSIS OF TENNIS RACQUET COMPOSITE GRIPS WITH RATIOS OF CARBON AND GLASS FIBRES

Ti-Yu Chen, Chung-Yu Chen, Der-Chia Lin and Chenfu Huang
National Taiwan Normal University, Taipei, Taiwan

The purpose of this study was to analyze the vibrations from different tennis racquet grip materials. For this study, five different kinds of tennis racquet grips were used. The materials in the actual grip were composed of a mixture of carbon fibre and glass fibre in the ratio of 10 to 0, 7 to 3, 5 to 5, 3 to 7, and 0 to 10. Two accelerometers and BioPAC system were used to acquire the vibrational signals. The results of this study indicated that the tennis racquet made of pure carbon fibre, had a higher damping ratio on the center and off-center impact. The damping ratio was significantly decreased as the content of glass fibre in the racquet was increased ($p<.05$). However, the value of the integral power spectrum was significantly increased ($p<.05$). Therefore, based on the vibrational analysis among the difference in material composition of tennis racquets, it concluded that increasing the content of glass fibre in the racquet would increase the load carried by the tennis player's arm.

KEY WORDS: racket, damping ratio, vibration, material

INTRODUCTION: There are many important elements to consider in selecting appropriate tennis equipment. However, it is obvious that the tennis industry is still thriving. Equipment will continue to improve. Manufacturers have contributed to improved equipment by identifying the need to inform players of what to look for in equipment and the way in which certain pieces of equipment might be of benefit to them. The trend of today's racquet industry is toward the use of substances such as viscoelastic polymers and graphite/fiberglass composites (Groppel, 1992). Of all the materials available, graphite is used most often and it is usually combined with fiberglass. The purpose of this study was to analyze the vibration of different materials used to manufacture tennis racquet grips, and to determine the effect of impact on the top, bottom, and center of the racquet face.

METHODS: Five different kinds of tennis racquet grip were chosen for this study. The materials used in their manufacture were composed by mixing carbon fiber and glass fiber in the ratio of 10 to 0, 7 to 3, 5 to 5, 3 to 7, and 0 to 10. All racquets used in the experiment had the same weight, string tension, stiffness and balance. The purpose of the study was to test the amount of vibration and to establish the damping ratio (first mode) by logarithmic decrement equation.

$$\ln\left(\frac{X_m}{X_{m+k}}\right) = k \cdot \frac{2\pi\zeta}{\sqrt{1-\zeta^2}}$$

ζ : damping ratio
X_m, X_{m+k}: amplitudes of two times
k: period number between two amplitudes

and the value of integral power spectrum.

Two accelerometers (2000 Hz) and BioPAC system were used to acquire the vibrational signals. The impact of the tennis ball was set for the velocity of 4.09 m/s. The selected variables in the experiments were tested by one-way ANOVA at α=.05 significant level.

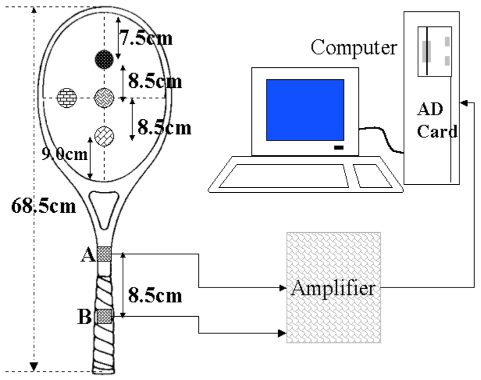

Figure 1 - Accelerometers (point A and B) measuring chain.

RESULTS AND DISCUSSION: The results of this study indicated that the pure carbon fibre racquet had a higher damping ratio on the center (0.070) and off-center (0.098; 0.102) impact (Table 1). The damping ratio was significantly decreased, as the content of glass fibre in the racquet was increased (Figure 2).

Table 1 The Mean and Standard Deviation of Damping Ratio with Various Tennis Racquet Grip Materials

Percentage of graphite / Impact position	100%	70%	50%	30%	0%
Center impact*	0.070	0.057	0.065	0.063	0.047
n=5	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Top impact*	0.098	0.070	0.053	0.047	0.053
n=5	(0.004)	(0.003)	(0.001)	(0.001)	(0.002)
Bottom impact*	0.102	0.065	0.051	0.052	0.044
n=5	(0.003)	(0.004)	(0.001)	(0.002)	(0.003)

( ) standard deviation *p<.05

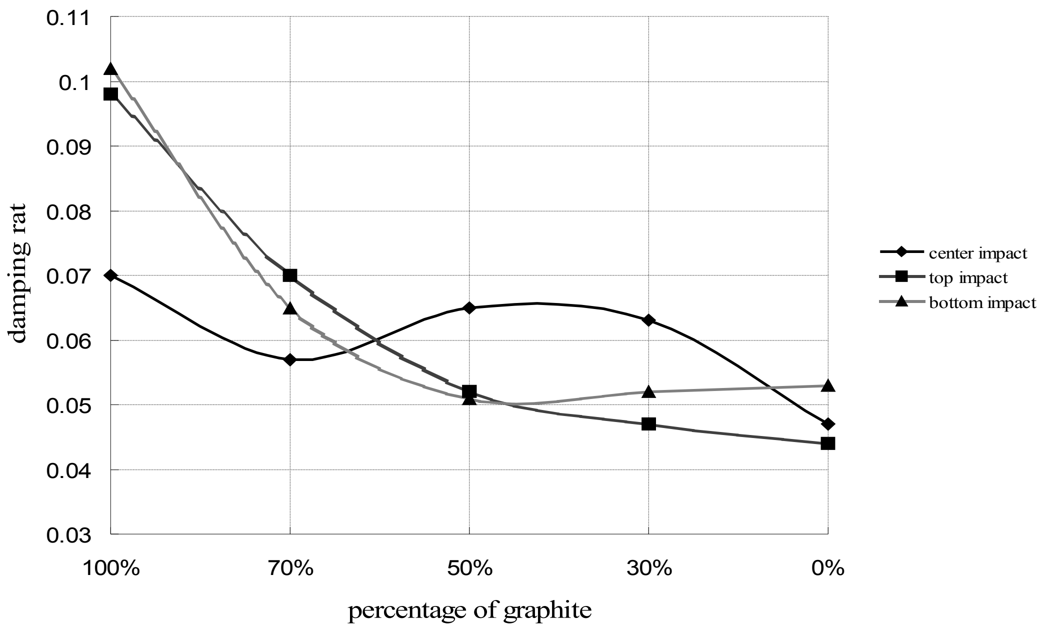

Figure 2 - Plots of damping ratio with various tennis racquet grip materials.

On the other hand, it indicated that the pure carbon fibre made racket had a lower value of integral power spectrum on the center (0.099) and off-center (0.107; 0.466) impact (Table 2). The value of integral power spectrum was significantly increased, as the content of glass fibre in the racquet was increased (Figure 3).

Based on the vibrational analysis of the different substances used in the manufacture of tennis racquets, it was concluded that by increasing the content of glass fibre in the racquet, the load on the tennis player's arm would also be increased. Therefore, indirectly, this phenomenon would affect the athlete's ability with regards to performance control. This study significantly confirmed those conclusions.

Table 2 The mean and standard deviation of integral power spectrum with various tennis racquet grip materials

Percentage of graphite / Impact position	100%	70%	50%	30%	0% 0 %
Center impact* n=5	0.099 (0.007)	0.260 (0.018)	0.293 (0.014)	0.322 (0.026)	0.442 (0.011)
Top impact* n=5	0.107 (0.008)	0.136 (0.013)	0.176 (0.018)	0.284 (0.017)	0.284 (0.026)
Bottom impact* n=5	0.466 (0.038)	0.730 (0.030)	0.836 (0.063)	1.074 (0.079)	0.836 (0.050)

( )standard deviation *p<.05

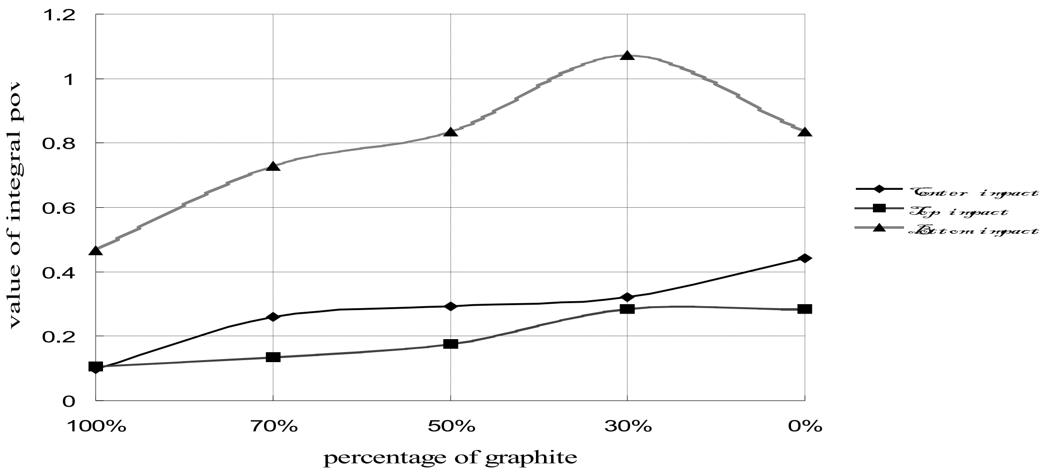

Figure 3 - Plots of the value of integral power spectrum with various tennis racquet grip materials.

CONCLUSION: The impact of the tennis ball was set at the velocity of 4.09 m/s. The results indicated that the racquet made from pure carbon fibre had a higher damping ratio and lower value of integral power spectrum on the center and off-center impact. The degree of vibration depended on the amplitudes and setting times. Based on the vibrational analysis among the differential material composition of tennis racquets, it concluded that by increasing the content of glass fibre in the racquet, it would be increasing the load in the tennis player's arm. Indirectly, this phenomenon would affect the athlete's performance.

REFERENCE:

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