THE VIBRATION AND COEFFICIENT OF RESTITUTION ANALYSIS IN TENNIS RACKETS VARIED WITH MATERIAL COMPOSITION AND FIBER ARRANGEMENT

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INTRODUCTION

The increase in power of modern tennis could be attributed to stronger, better conditioned players, but the major reason was the modern racket of the consistent power making it possible (Groppel, 1992). However, there are strong indications that impact shock and post-impact vibration transfer in tennis racquet may lead to the epicondylitis humeri syndrome. This study was to investigate how the vibration on wrist joint of the player and rebounding velocity of the ball from each racket were affected by the vibration of various tennis rackets which were composed by the mixture of carbon fiber and glass fiber.

METHODS

There were eight different kinds of tennis racket, composed by mixing carbon fiber and glass fiber in the ratio of 1 to 0, 6 to 1, 5 to 2, and 4 to 3. The angles of the fiber were arranged in 22 degrees and 30 degrees with respect to the longitudinal axis.

The experiment 1 was to monitor the vibration on the wrist joint of participant and to find the logarithmic decrement ratio of vibration. Accelerometer was attached to participant's wrist joint to acquire the vibratory signals. The logarithmic decrement ratio, δ, was calculated using,

$$\delta = \ln\left(\frac{X_m}{X_{m+k}}\right)$$

where X_m and X_{m+k} are the amplitudes of vibratory wave between k periods.

For experiment 2, Peak Motus system with one high-speed video camera was used to record the kinematics data and to calculate the coefficient of restitution. The coefficient of restitution, e, was calculated using,

$$e = -\frac{V'}{V}$$

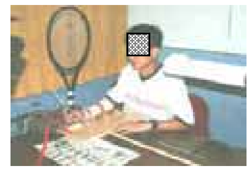

Figure: The accelerometer (attached to the wrist joint of participant) measuring chain.

where V and V' were the pre-impact and post-impact ball velocities.

RESULTS AND DISCUSSION

The results of the vibration logarithmic decrement ratio on wrist indicated that the pure carbon fiber made racket at 22 degrees had a higher value, and the value was significantly increasing as the content of carbon fiber in the racket was increasing. On the other hand, pure carbon fiber made racket had higher stiffness that its coefficient of restitution was higher than glass fiber made racket. This phenomenon indicated that the wrist joint would absorb more vibratory energy from racket made by pure carbon fiber.

CONCLUSIONS

By increasing the content of glass fiber in the racket, it might be decreasing the load in the tennis player's arm on center or off-center impact. But it would affect the performance on ball rebound. On the other hand, the rackets with fiber angle at 22 degrees had lower vibration than that at 30 degrees.

REFERENCES

Groppel, J.L. (1992). *High Tech Tennis* (2nd ed.), 15-27. Champaign, IL: Leisure Press Inc.

Table: The mean and standard deviation of vibration logarithmic decrement ratio (δ) and the coefficient of restitution (e) with various tennis rackets material and fiber angles (mean ± SD)

Fiber Angle	Percentage of Carbon							
	100%		86%		71%		57%	
	δ	e	δ	e	δ	e	δ	e
22 Degrees								
Center Impact	2.14±0.13	0.33±0.02	1.68±0.12	0.31±0.01	1.86±0.37	0.32±0.02	2.16±0.16	0.32±0.02
Top Impact	1.71±0.10	0.16±0.02	1.41±0.10	0.13±0.03	1.58±0.24	0.11±0.02	1.25±0.10	0.11±0.02
Bottom Impact	0.42±0.07	0.37±0.02	0.65±0.07	0.36±0.02	0.57±0.15	0.36±0.04	0.77±0.06	0.32±0.01
30 Degrees								
Center Impact	2.04±0.14	0.32±0.01	1.21±0.16	0.30±0.02	1.71±0.22	0.31±0.03	1.29±0.08	0.31±0.02
Top Impact	1.15±0.07	0.16±0.01	1.40±0.10	0.15±0.01	1.16±0.07	0.12±0.01	1.35±0.12	0.13±0.03
Bottom Impact	0.73±0.14	0.41±0.02	0.61±0.07	0.37±0.02	0.56±0.08	0.35±0.02	0.69±0.14	0.34±0.02