Vibrational Variability in Padel Rackets: Insights into Performance and Equipment Design

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Summary

The vibrational behavior of padel rackets can vary due to variations in manufacturing processe and racket design, which can impact player performance and perception. This study investigates whether variations in vibrational behavior can be detected both between different racket models and samples of the same model under play conditions. Nine rackets were tested by measuring vibration signals at the racket center and and extracting temporal descriptors from these signals. Significant variations between samples and models were found.

Introduction

Sensory stimuli, including tactile and auditory inputs, have a notable impact on the performance and experience of equipment or motion [1-2]. In the case of golf clubs, the overall RMS (Root Mean Square) value of the vibrations transmitted to the forearm is linked to the perceived qualities of the material, such as its pleasantness, solidity, and vibration intensity [1]. For racket paddles, subjective comfort and control ratings are found to be strongly related to time and frequency characteristics [2]. One industrial challenge that remains is the repeatability of mechanical characteristics in the padel racket manufacturing process. Because of the variability that occurs due to discrepancies in the manufacturing process, the player's performance could be impacted and their acceptance of the equipment may be influenced. The goal of this study is to investigate whether variations in vibrational behavior among different racket samples and models can be detected under play conditions.

Methods

The experiment consisted in sending a series of ten balls onto a racket held by a subject in a volley position. Nine new rackets in total—six samples of model M1, one sample for each model M2, M3, M4—were examined. Using a ball launcher (Slinger Bag, Slinger LLC, Windsor Mill, MD, USA) the balls could be launched at 12.5 ±0.3 $m.s^{-1}$. Before each impact and for each racket, the player was instructed to get back to the same grip conditions and racket positions. An accelerometer (PCB Piezotronics Inc., USA, type 352A25SN, 2 mV/g, ± 2000 g pk, [1-10k] Hz) was placed at the center of the racket and connected to an acquisition card (NI, USA, type 9234, Fs: 48kHz). Acceleration signals were filtered (Butterworth, 4th order, zero phase shift) with a 20 Hz cut-off. Each signal was segmented around the impact (detected by the maximum amplitude value) with the time band [-5;50] ms. The RMS value and energy decay curve (EDC) were then extracted from these segmented signals. The T20 was extracted from the EDC as the instant at which 20% of the energy of the signal remains. Means and confidence intervals (95%) of both RMS and T20, as well as one-way ANOVA and post hoc tests were performed to find significant differences between rackets.

Results and Discussion

Only T20 values show significant differences across samples and models (Figure 1). Since T20 lasts around 2.6 to 6.5 ms, a significant amount of energy remains throughout the impact duration (4-6 ms), which could affect the perception of racket control or comfort.

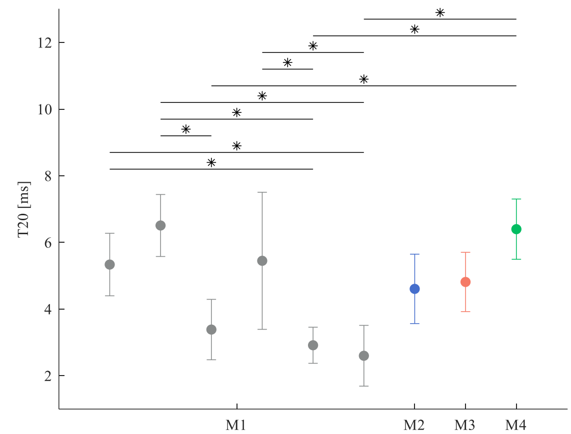

Figure 1: T20 values (means and confidence intervals, *: $p<0.05$) of all models (M1 to M4, shown by each color) and samples (for M1).

Conclusions

Decay time proved to be a reliable discriminator between padel rackets. Further research is now needed in order to a) check if mechanical properties (e.g. inertia, modal frequencies) of the rackets explain the results, b) if the results hold for different shots or racket wearing levels, and c) whether the players are sensitive to the differences in T20. Further research is needed to determine their whether players can perceive differences in comfort and control during real-game situations.

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References

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