SOUND FROM RESONANCES IN SPORTS EQUIPMENT: CAN IT BE USED TO EVALUATE ATHLETIC PERFORMANCE ?

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1. INTRODUCTION

Physicists have conducted extensive analyses of various sports such as tennis(1) and baseball(2) using many measurement techniques. However, only timing devices, whether a stop-watch for track or a radar gun for baseball, are presently available to provide real-time non-obtrusive performance evaluation. It is proposed that with the advent of sophisticated hand-held analyzes (7), acoustics, specifically the sound generated by resonances in sports equipment, may provide a valuable tool for real-time analysis of athletic performance.

2. SOUND FROM INFLATED SPORT BALLS

Volleyball, soccer, football and basketball all use an air inflated ball, which when struck such as "spiking" a volleyball and kicking a football or soccer ball, produces a significant level of sound with stable characteristics. This is caused by the excitation of the fundamental "breathing" mode as shown in Figure 1 for a "spiked" volleyball(3).

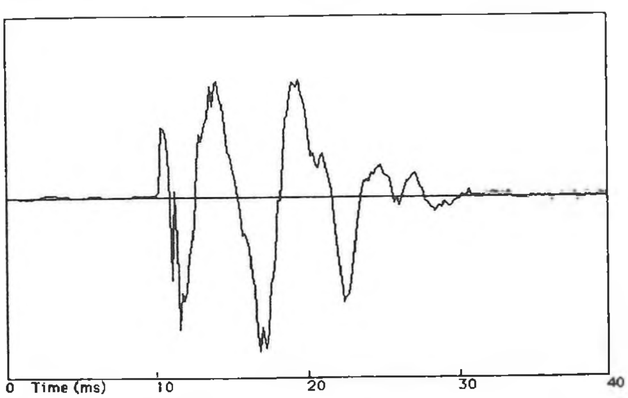

Figure 1. Sound from "spike".

The fundamental frequency was found to be approximately 150 Hz. The corresponding frequency spectrum for the volleyball "spike" is shown in Figure 2. Similar results were obtained from "dribbled" basketballs and kicked footballs(3) and were in agreement with the theory of Morse and Feshbach(4).

3. ALUMINUM SOFTBALL BATS

Perhaps an even more striking example is the sound from an aluminum softball bat. With the commonly used "Bottle Bat" design The hitting area is a uniform cylinder with a minimum wall thickness to increase the "trampoline" effect. Hitting a softball excites a rich set of modal vibrations in the bat. Figure 3. shows the acoustic signature from an aluminum softball bat struck lightly near the outward end of the cylinder. the corresponding acoustic spectrum is shown in Figure 4.

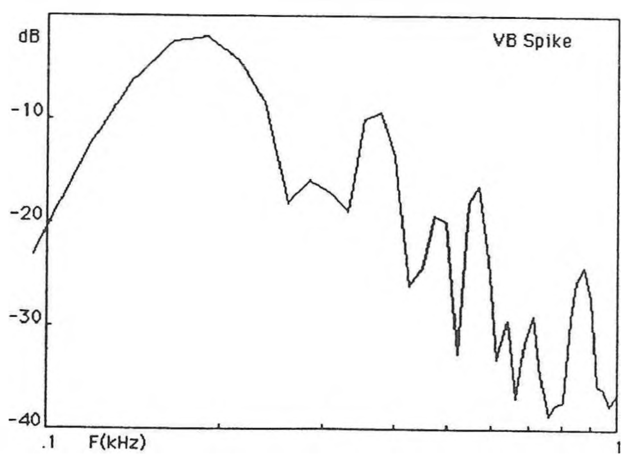

Figure 2. Acoustic spectrum of "spiked" volleyball.

4. ANALYSIS

For the inflated sport balls it was found(3) that the amplitude of the acoustic signal could be used to straightforwardly determine a "good"from a "poor" hit. In addition, the most efficient coupling from the initial impact on the ball (the hand slap when "spiking" a volleyball, for example) to the larger amplitude of the ball resonance determined the"sweetest" hit and could be easily detected acoustically.

The aluminum softball bat with its multi-mode excitation provides an even greater potential for analysis. For example, it was easily demonstrated that the location of the ball impact on the bat could be determined from the frequency spectrum of the sound produced.

5. CONCLUSIONS

In many sports acoustics appear to have the potential to be a valuable tool for the in situ analysis of athletic performance. The further development of hand-held analyzers to include replica-correlation and other processing techniques should ehance this unique capability.

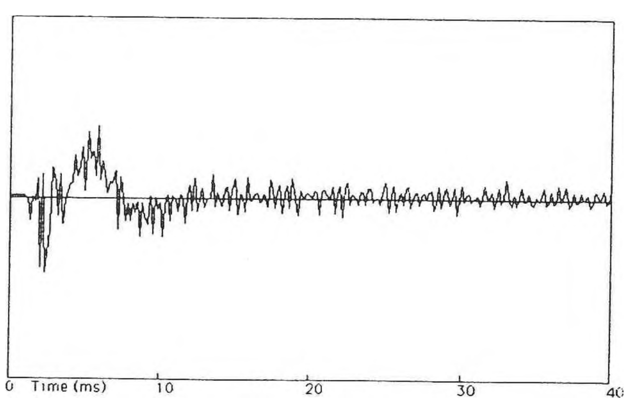

Figure 3. Sound from aluminum softball bat struck near out-ward end of cylinder.

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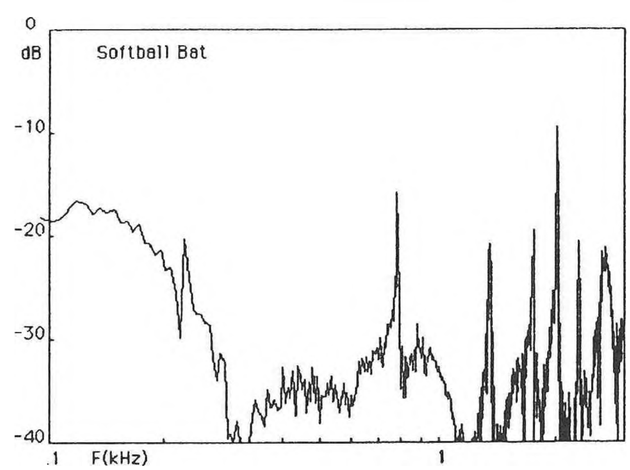

Figure 4. Acoustic spectrum of aluminum softball bat. Hit near end.