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The Nature of Noise Control

Is pickleball noise highly impulsive?

Naomi Jensen[1], Samuel Hord, Francisco Irarrazabal, Mike Dickerson, Matthew Baldwin, Jordan Trubakoff, Bethany Wu, Drew Gibson, Robert Pearson
MD Acoustics, LLC
170 S. William Dillard Dr. Ste 105
Gilbert, AZ

ABSTRACT

Pickleball is one of the fastest-growing sports in the United States. With the number of pickleball players and courts increasing, the distinct noise associated with pickleball is becoming a common feature in suburban soundscapes. Community opposition to new pickleball courts often cites nuisance noise as a cause of concern for new court development. Should new community noise metrics be developed for this emerging sport? Currently, many in the acoustics community are debating if pickleball noise should be described as "regular impulsive", or even "highly impulsive". Thus, this paper seeks to understand how pickleball noise compares with other regular and highly impulsive sounds. Acoustical measurements of pickleball paddles are compared to regular impulsive sounds (ping pong paddles, basketball dribbles, tennis rackets) and highly impulsive sounds (hammer hits and small arms fire). Acoustical signatures and overall sound levels of the various impulsive noises are compared, and recommendations for characterizing the noise impacts of pickleball are presented.

1. INTRODUCTION

Pickleball is a tennis-like sport that is often played on an outdoor court. It is typically played in singles (2 players) or doubles (4 players) and involves hitting a plastic wiffle-like ball across the court with a fiberglass/composite paddle. The sound of a pickleball hitting a paddle is often characterized by a "popping" sound, with a short impulse duration of 10-15 milliseconds (ms) [1]. With pickleball's growing popularity in the US, concerns over sounds associated with pickleball play are emerging in communities near developing pickleball courts. Of particular interest is whether to categorize pickleball noise as "regular impulsive" or "highly impulsive".

1.1. ISO Definitions

ISO 1996-1 "Acoustics – Description, measurement and assessment of environmental noise – Part 1" gives the following definitions (and sub-definitions) for varying types of impulsive sound [2]:

3.4.8 impulsive sound Sound characterized by brief bursts of sound pressure.
NOTE The duration of a single impulsive sound is usually less than 1 s.

[1] naomi@mdacoustics.com

3.5 Impulsive sound sources
NOTE Currently, no mathematical descriptor exists which can define unequivocally the presence of impulsive sound or can separate impulsive sounds into the categories given in 3.5.1 to 3.5.3. These three categories, however, have been found to correlate best with community response. Thus the sources of sound listed in 3.5.1 to 3.5.3 are used to define impulsive sound sources.

3.5.1 high-energy impulsive sound source
any explosive source where the equivalent mass of TNT exceeds 50 g, or sources with comparable characteristics and degree of intrusiveness

EXAMPLES
Quarry and mining explosions, sonic booms, demolition or industrial processes that use high explosives, explosive industrial circuit breakers, military ordnance (e.g. armour, artillery, mortar fire, bombs explosive ignition of rockets and missiles).

NOTE Sources of sonic booms include such items as aircraft, rockets, artillery projectiles, armour projectiles and other similar sources. This category does not include the short duration sonic booms generated by small arms fire and other similar sources.

3.5.2 highly impulsive sound source
any source with highly impulsive characteristics and a high degree of intrusiveness

EXAMPLES
Small arms fire, hammering on metal or wood, nail guns, drop-hammer, pile driver, drop forging, punch presses, pneumatic hammering, pavement breaking, or metal impacts in rail-yard shunting operations.

3.5.3 regular impulsive sound sources
impulsive sound sources that are neither highly impulsive nor high-energy impulsive sound sources

NOTE This category includes sounds that are sometimes described as impulsive, but are not normally judged to be as intrusive as highly impulsive sounds.

EXAMPLES
Slamming of a car door, outdoor ball games such as football (soccer) or basketball, and church bells, Very fast pass-bys of low-flying military aircraft may also fall into this category.

1.2. Relevance to Pickleball Noise

The distinction of pickleball noise as “regular impulsive” or “highly impulsive” affects how acousticians assess the environmental effects of pickleball noise. Table 2 of ANSI S12.9-2005/Part 4 [3] suggests a 5 dB adjustment for noises categorized as “regular impulsive” and a 12 dB adjustment for noises categorized as “highly impulsive”. Mark Storm presented ANSI and ISO standards for impulsive noises and argued that “it is prudent to apply only the 5 dB adjustment associated with regular impulsive sounds as that would be conservative and already consistent with what commonly appears in community noise assessment criteria” [4].

This paper seeks to further investigate pickleball noise in comparison to these ANSI/ISO definitions. The pressure waveform of a pickleball paddle hit will be characterized and compared to pressure waveforms of defined "regular impulsive" noises (such as outdoor ball game noises) and "highly impulsive" noises (such as hammer hits and small arms fire). In so doing, the author hopes to elucidate what waveform characteristics may be associated with "regular impulsive" vs. "highly impulsive" sounds.

2. EXPERIMENTAL METHODS

2.1. Measurements

The acoustic sources of impulsive noise that were measured and analyzed for this paper are: pickleball paddle, basketball, ping pong paddle, tennis racket, and hammer hitting nails into wood. Sound pressure measurements of each acoustic source were taken using two PCB 378B02 microphone/preamplifiers and in accordance with ANSI/ASA S12.55-2012. All measurements were conducted in an anechoic chamber with the exception of the basketball and tennis measurements, which were taken in an outdoor setting. Figures 1 and 2 show the measurement process for a pickleball paddle and basketball respectively.

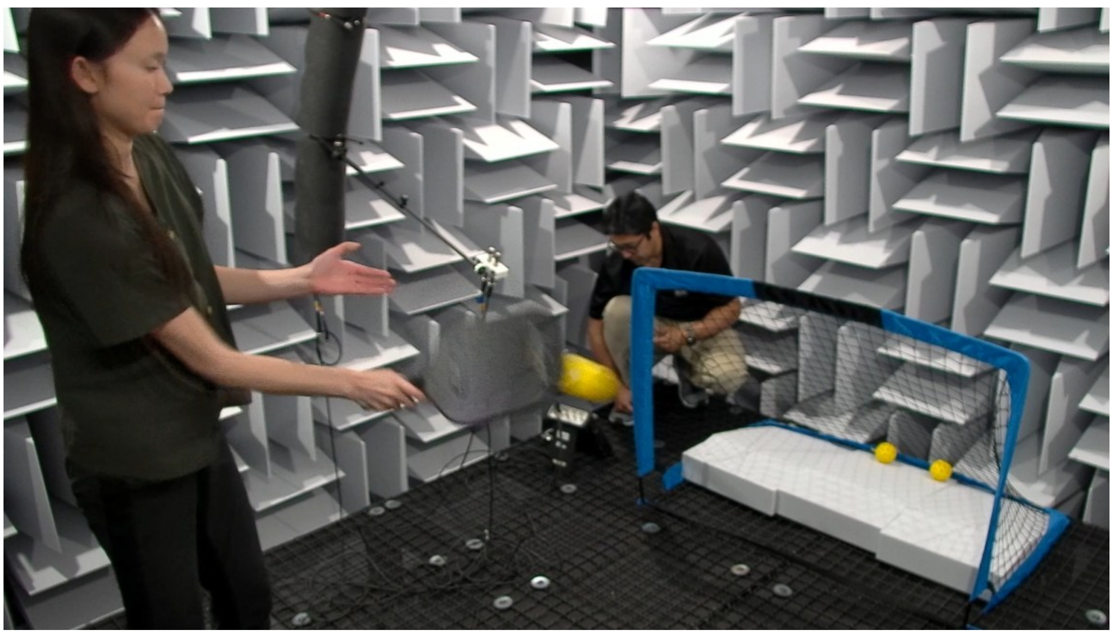

Figure 1: The sound pressure measurement set up for a pickleball paddle.

<Figure 2, next page>

Figure 2: The sound pressure measurement set up for the basketball bounce.

Measurements of pickleball noise were taken of seven (7) pickleball players using three (3) types of pickleball paddles: Dingk Carbon Pro Grit, Paddletek Tempest Wave Pro, and Kourt Shark TDX-1. The ping pong measurements used one player and one wooden Penn ping pong paddle. The microphones for the pickleball and ping pong paddle measurements were placed approximately 3 feet from the paddle impact and at a 45-degree angle from the plane of incidence. Measurements of the Spalding basketball were taken approximately 6 feet away from the basketball bounce onto the outdoor concrete surface, and measurements of the tennis racket were made approximately 5 feet from the racket.

2.2. Post-processing

Post-processing of the pressure data was performed in MATLAB. The largest impulse of each acoustic source was chosen for comparative purposes across the source types and as a worst-case scenario. All sound sources were analyzed using a 15-ms time window for comparative purposes.

3. RESULTS

Figure 3 shows the sound pressure measurement of the loudest pickleball paddle hit at a distance of 3 feet. The impulse duration of the pickleball paddle hit was approximately 0.01 seconds (10 ms). This is consistent with Moore's findings [1] on the impulse durations of pickleball paddle impacts. The peak rms pressure level was 19.6 pascals corresponding to an LZpeak level of 120 dB.

<Figure 3, next page>

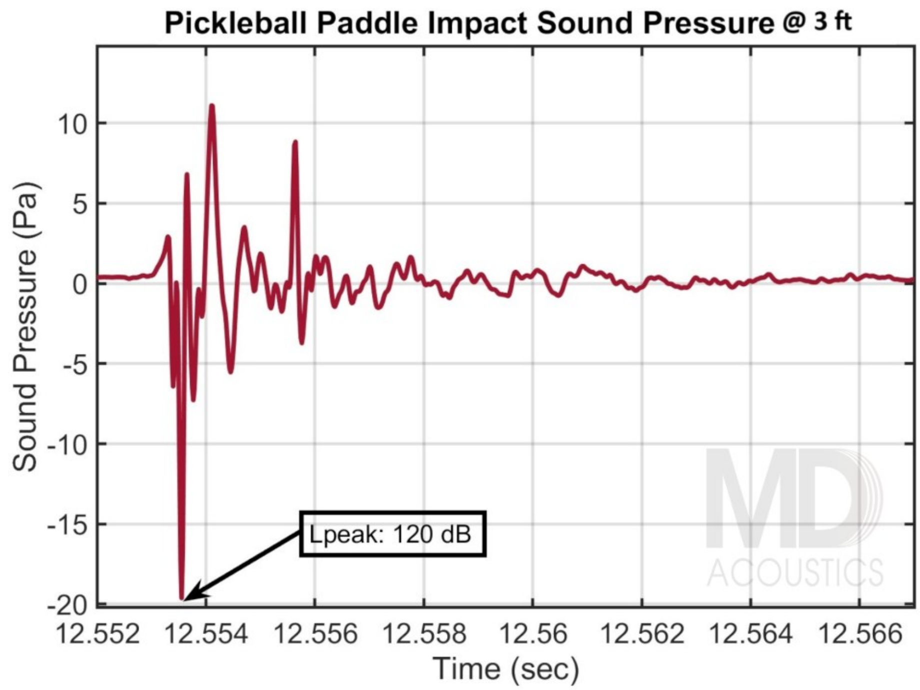

Figure 3: The sound pressure level of the loudest pickleball paddle hit.

Figure 4 shows the sound pressure measurement of the loudest basketball bounce at a distance of 6 feet. The impulse duration of the basketball hit was longer than that of the pickleball paddle. The peak rms pressure level was 17.5 pascals corresponding to an LZpeak level of 119 dB. As shown in Figure 2, the basketball bounce was performed by a 6'3" man weighing approximately 240 lbs smashing the ball as hard as possible into the concrete. The pressure reported here is not typical of the sound of a basketball being dribbled or landing on the concrete after a shot.

<Figure 4, next page>

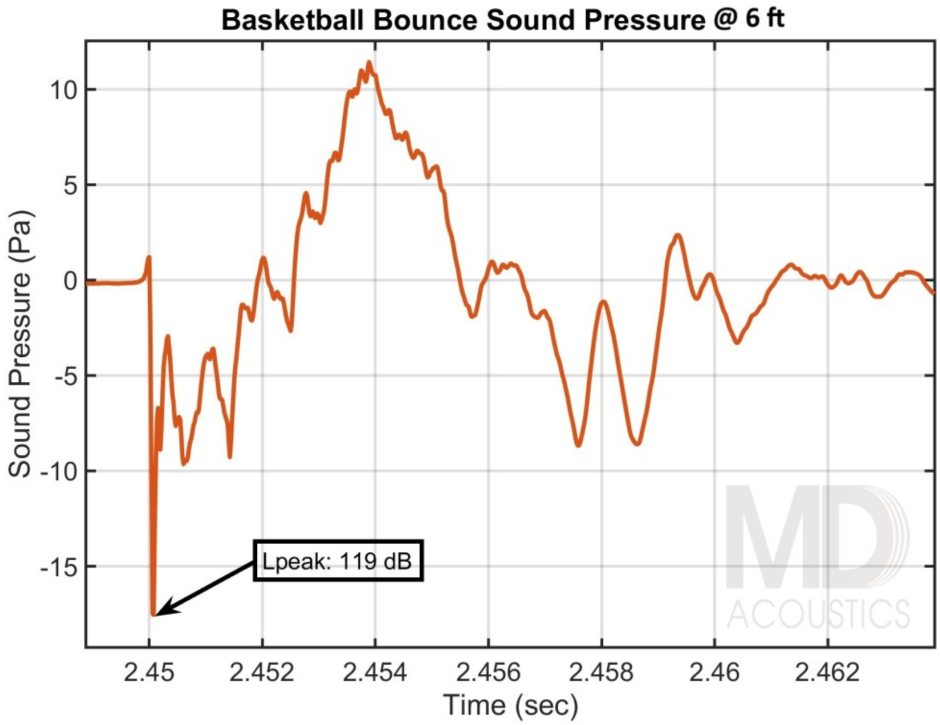

Figure 4: The sound pressure level of the loudest basketball bounce on asphalt.

Figure 5 shows the sound pressure measurement of the loudest ping pong paddle hit at a distance of 3 feet. The peak rms pressure level was 14.2 pascals corresponding to an LZpeak level of 117 dB.

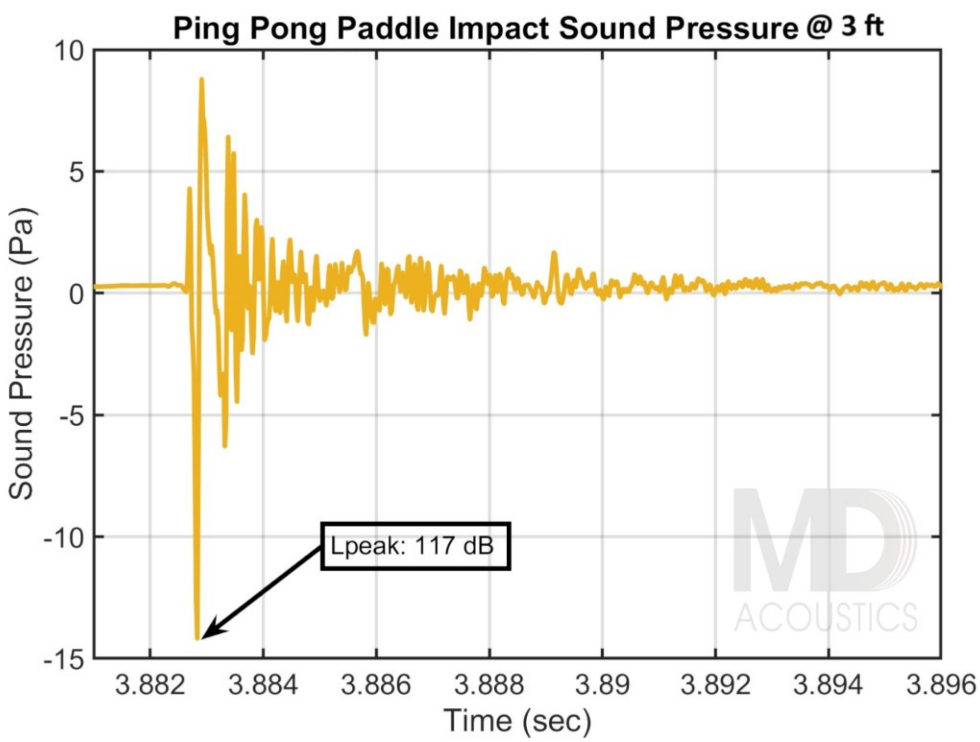

Figure 5: The sound pressure level of the loudest ping pong paddle hit.

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Figure 6 shows the sound pressure measurement of the loudest tennis racket hit a distance of 5 feet. The peak rms pressure level was 4.1 pascals corresponding to an LZpeak level of 106 dB.

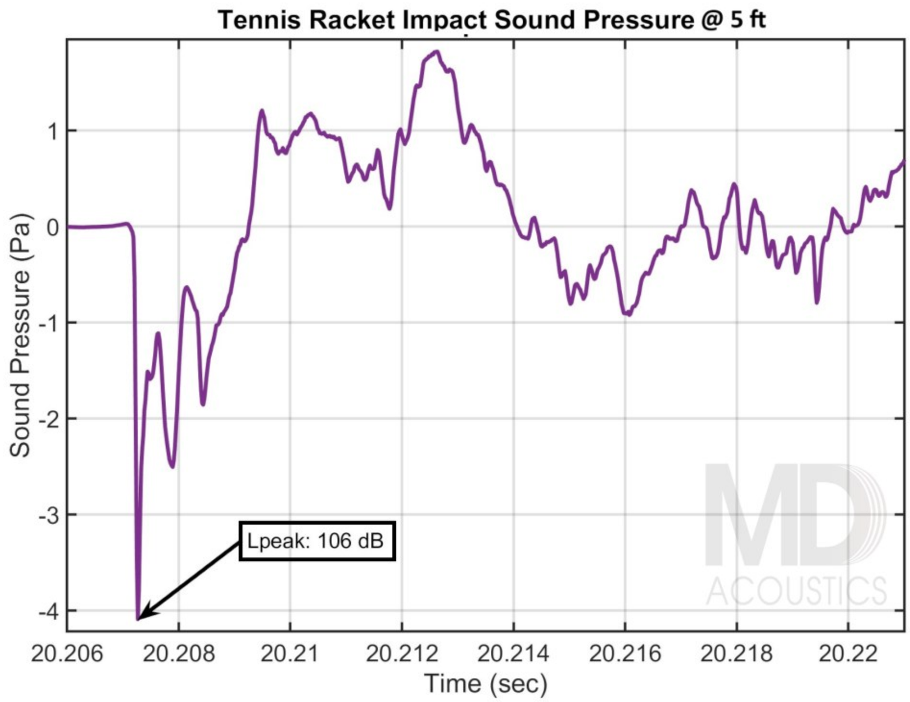

Figure 6: The sound pressure level of the loudest tennis racket on tennis ball hit.

Figure 7 shows the sound pressure measurement of the loudest hammer impact at a distance of 4 feet. The peak rms pressure level was 41.1 pascals corresponding to an LZpeak level of 126 dB.

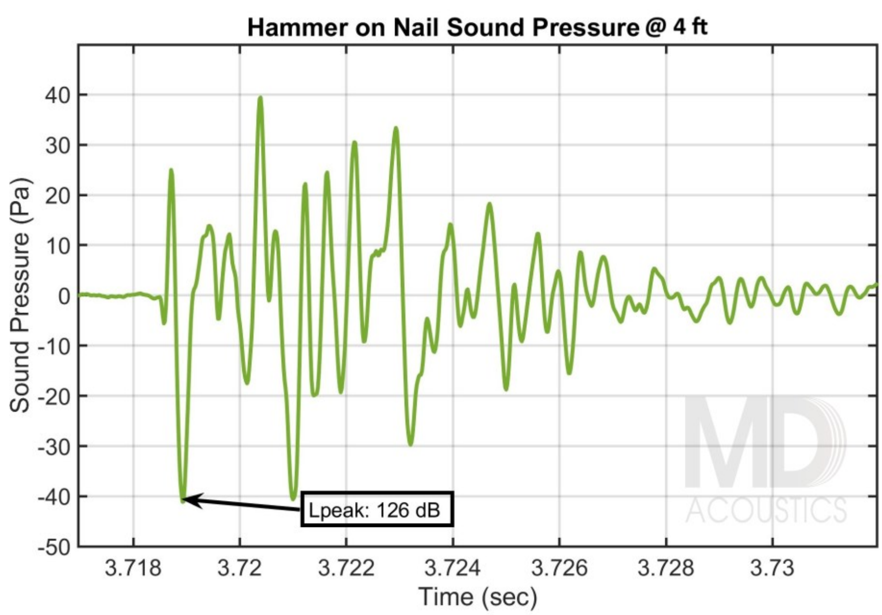

Figure 7: The sound pressure level of the loudest hammer on nail hit into wood.

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In an internal study, MD Acoustics performed sound pressure measurements of a 9 mm handgun at a distance of 33 feet (10 meters). The recorded sound pressure level of the 9 mm handgun is shown in Figure 8. The peak pressure level was about 285 pascals corresponding to an LZpeak level of 143 dB. Notably, the impact duration is on the order of 10 times smaller than that of the pickleball paddle hit.

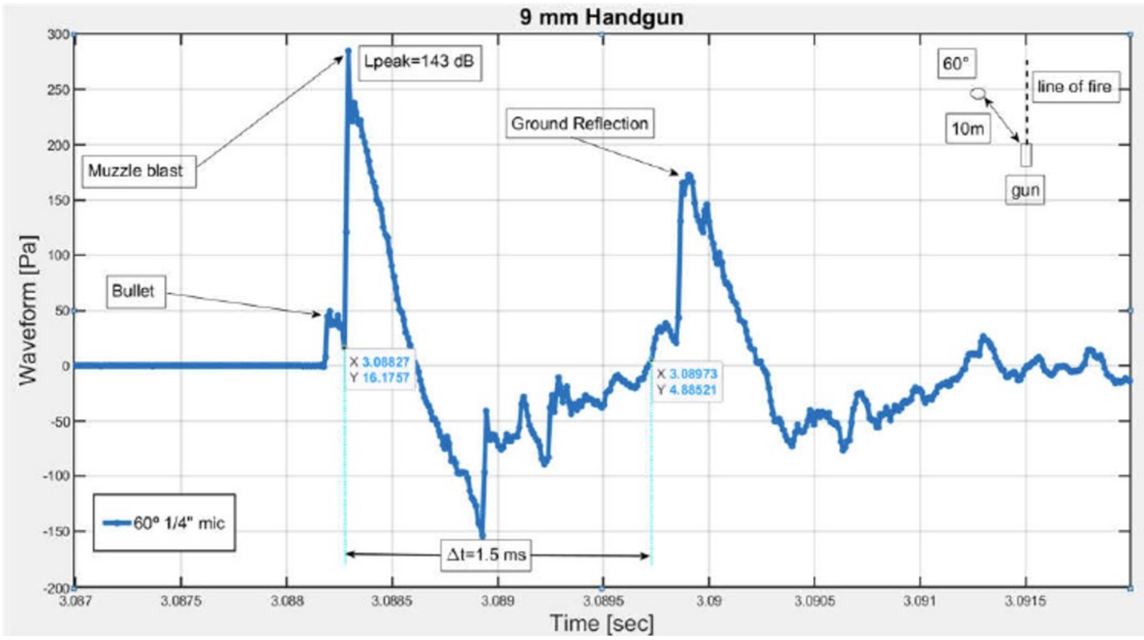

Figure 8: The sound pressure level of the 9 mm handgun at 33 ft (10 m) performed by MD Acoustics.

Table 1 summarizes the sound sources analyzed in this study and compares the loudest recorded pressure levels and LZpeak values associated with each sound source.

<Table 1, next page>

Table 1: Comparison of sound source, maximum rms pressure, and LZpeak.

Source	Maximum Pressure (Pa)	Distance from Microphone (ft)	Recorded LZpeak (dB)	Normalized LZpeak @ 33 ft (dB)
Pickleball paddle	19.6	3	120	99
Basketball bounce	17.5	6	119	104
Ping pong paddle	14.2	3	117	96
Tennis racket	4.1	5	106	90
Hammer on nail, wood	41.1	4	126	108
9mm Handgun	285	33	143	143

All tested recreational noise sources measured less than 105 dB LZpeak at a distance of 33 feet (10 meters). All highly impulsive noise sources measured more than 105 dB LZpeak at 33 feet (10 meters). As a starting point for a quantitative distinction between regular and highly impulsive noise sources, MD recommends 105 dB LZpeak at a distance of 33 feet (10 meters) for consideration.

Both the hammer hit and the 9 mm handgun fire can be classified as "highly impulsive sound sources" under the examples given in ISO-1996-1 3.5.2. The hammer hit data was taken at a distance of 4 feet, while the pickleball noise was taken at a distance of 3 feet. At 3 feet, the hammer hit reached an LZpeak level of approximately 129 dB, 9 dB above the LZpeak level of the pickleball paddle. The human ear perceives a 10 dB increase to be twice as loud, so a 9 dB difference results in the perceived loudness nearly doubling from a pickleball hit to a hammer hit. The 9 mm handgun fire reached a maximum rms pressure of 285 pascals and 143 dB LZpeak at a distance 10 times greater from the source. The peak pressure level at a comparable distance would be about 3000 pascals, or 164 dB LZpeak. These values are orders of magnitude larger than those of pickleball noise. At these peak pressures, the handgun noise presents nonlinear behavior, while the pickleball noise analyzed in this study is linear. The over 20 dB increase from the pickleball paddle LZpeak to the handgun LZpeak equates to the handgun being perceived over 4 times as loud as the pickleball paddle. The author finds handgun waveform characteristics (including maximum pressure, LZpeak value, perceived loudness, and impulse duration time) to be enough to classify handgun noise as clearly distinct from pickleball noise. The distinction between the hammer impact noise and pickleball noise remains less readily apparent, but pickleball noise's similarity to other outdoor recreational noises stays clear.

All presented measurements represent the loudest single impulses that MD measured during the testing and are not representative of typical or average impulses of the sources measured. For example, after measuring seven (7) participants hitting pickle balls in an anechoic chamber with three (3) different paddles, Figure 3 shows the loudest impulse produced by any combination of players and paddles. Over the seven (7) participants who hit the pickleball paddle for this study, impulse pressure amplitudes ranged from 2 to 20 pascals. Many factors likely account for this variation, including type of pickleball paddle and speed at which the pickleball was hit. An understanding of these metrics would help contextualize these sounds in relation to how they are currently affecting community noise environments.

4. CONCLUSIONS

The pressure wave forms of many impulsive sounds were analyzed. The loudest impact sounds from each source were characterized and compared to one another. The pickleball noise characteristics (including peak pressure, LZpeak, and impulse duration) were found to be more similar to other outdoor ball game noises than to hammer hits or small arms fire. Thus, per ISO and ANSI definitions, the author believes the term “regular impulsive” better describes the noise impacts from pickleball rather than “highly impulsive”. A 105 dB Lzpeak at a distance of 33 feet (10 meters) may be a starting point to consider a quantitative distinction between impulsive and highly impulsive sounds. Further studies are needed to clarify a potential quantitative distinction between regular impulsive noise and highly impulsive noise.

ACKNOWLEDGEMENTS

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REFERENCES

1. Moore, J. Pickleball Sounds: Impact Induced Vibration and Radiated Sound. *Proceedings of NOISE-CON24,* pp. 302-313(12). New Orleans, USA. June, 2024.
2. International Organization of Standardization (ISO) 1996-1:2003(E) *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures.* Second edition. August 1, 2003.
3. American National Standards Institute/Acoustical Society of America (ANSI/ASA), *Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response,* S12.9 2005 Edition.
4. Storm, M. The pickleball seven decibel challenge. *Proceedings of NOISE-CON24,* pp. 780-787(8). New Orleans, USA. June, 2024.