Article

How Loud are Noise Levels of Baseball Stadium? Assessment of Noise Levels and Attitude toward the Stadium Noise in Korea

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Abstract: This study measures the noise levels in a baseball stadium and analyzes baseball fans' attitude of effect of recreational noise exposure on their hearing. In the baseball stadium, noise levels were measured in four seating sections using a sound level meter during the games. The LAeq average of the 16 measures produced 91.7 dBA, showing a significantly high noise level in the red and navy sections. As a function of frequency by LZeq analysis, the noise levels were significantly higher in low frequencies than other frequencies. For the survey sample, 688 randomly selected participants completed a 16-question survey on their noise exposure during the game and on the potential risk of hearing loss. Despite the very high noise levels, 70% of the respondents preferred sitting in either the red or the navy section to be closer to the cheerleaders and to obtain a good view. Most respondents reported that they did not consider wearing earplugs, and one-third experienced hearing muffled speech after the game. We conclude that the noise levels in baseball stadiums are high enough to cause hearing damage and/or tinnitus later, but expect these results to improve public education regarding safe noise exposure during popular sports activities.

Keywords: noise of baseball stadium; recreational noise exposure; survey of noise exposure; noise-induced hearing loss

1. Introduction

A dangerously high level of noise is one of the factors estimated to affect acquired hearing loss [1]. Thus, numerous researchers have studied the characteristics of occupational noise and employees' risks of hearing damage from past exposure to such noise [1,2]. Noise-induced hearing loss (NIHL), which usually includes damage to cochlear hair cells, can be caused by a one-time exposure to a loud sound as high as 120 decibels (dB) as well as by repeated exposure to sounds at a level of 85 dB for 8 hours. Most countries, thus, limit the sound exposure level to less than eight hours at 85~87 dBA with a 3-dB or 5-dB exchange rate as occupational NIHL criteria [3,4].

More recently, the focus has shifted from occupational noise exposure to noise exposure in recreational settings, especially for young adults who frequently attend nightclubs [5], fitness classes [6], and sporting events [7]. According to the World Health Organization (WHO), regular participation in recreational settings with high noise levels may carry a serious threat of irreversible hearing loss [8] because the average sound levels in nightclubs and pop concerts have been reported to be as high as 100 dB SPL. In addition, the noise level at sporting events such as the Football World Cup in 2010 ranged from 80 dBA to 117 dBA, implying that even a short duration of such noise exposure can result in temporary or permanent hearing loss and/or tinnitus. Furthermore, Kujawa and Liberman found that certain pathological changes in the inner ear initiated by early noise exposure created shifts in the hearing threshold of the auditory system of young mice [9]. They

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suggested that noise exposure at high levels can accelerate age-related hearing loss (or presbycusis) in young people, who consequently experience significant communication difficulties and related psychosocial problems later in life [8].

Increasing numbers of spectators are crowded into various sporting events, thus experiencing a strong affinity while cheering together for their favorite players. Globally, one of the most popularly viewed sports is baseball [10]. The United States has 163 baseball stadiums, including 30 large ones for major league baseball [11]. As many as 73.8 million people watch baseball games every year [12]. South Korea has nine baseball stadiums, which hosted more than 7.5 million people for games. In addition, numerous special events are provided for baseball fans [13], and each team has its own character doll and photo zone. Children can naturally learn about baseball from a star player as a junior member. In sum, baseball enables family members of various ages to spend time together at a stadium. Although baseball stadiums are subject to high noise levels because of intense cheering during a competition, little attention has been paid to this noise level and its risk to spectators during and after a baseball game. With regard to basketball, Morris et al. estimated noise levels during games and reported that the average noise level and peak noise level were approximately 83 dBA and 126 dBA, respectively. These researchers concluded that the noise levels occurring during games were much higher than people expected and that frequent exposure to such levels could negatively affect the health of spectators and stadium employees [7]. In a study on health clubs, Yaremchuk & Kaczor [6] found that the noise levels at 125 health clubs ranged from 78 to 106 dBA. In addition, 50% of trainers employed in the health clubs experienced ear pain and suffered from tinnitus. Although the noise levels produced at different sporting events should be measured and compared, there is a lack of research characterizing noise types and levels in public sports. Thus, scientific documentation has been insufficient in providing accurate information regarding the risks associated with high noise levels and exposure time [14]. Furthermore, the general public underestimates the hearing problems associated with loud noise and does not acknowledge noticeable damage [15], despite the fact that sporting events can leave spectators with muffled hearing and/or tinnitus; indeed, high noise exposure causes fatigue in the ear's sensory cells [16]. In this light, this study measures the noise levels generated during a baseball game and analyzes four different sections. In addition, the study scrutinizes people's awareness of potential hearing damage related to noise exposure at a baseball stadium. We hypothesize that a large baseball stadium has different noise levels even during one game and that spectators will not recognize any sign of hearing problems caused by high levels of noise exposure in the baseball stadium due to a tradeoff with recreational activity [14,15]. These findings will provide scientific information and effective guidelines for the public regarding safe noise exposure at recreational activities.

Part 1: Baseball Stadium Noise Level

2. Materials and Methods

2.1. Characteristics of Baseball Stadiums

To measure noise levels during a baseball game, the study uses the Seoul Complex Sports Baseball Stadium. This facility is the largest baseball stadium in Korea, spanning 125 meters from home to center and 100 meters between the left and right fences, with a fence height of 2.6 meters. Every year, approximately 130 games are held there, and 2.3 million people visit the stadium. The Seoul Complex Sports Baseball Stadium includes four seating areas: red, blue, navy, and outfield (see an aerial view of the stadium in the left panel of Figure 1). Each section has a different attraction for spectators. For example, the red section is the most popular because it is closest to the cheerleaders and the ground. The blue section is best for watching the players and the game and is also close to the cheerleaders; however, its price is relatively expensive. When seated in the navy section, people can see the entire game. The outfield, with its inexpensive ticket price, is preferred by many families or people who want to watch the game more quietly.

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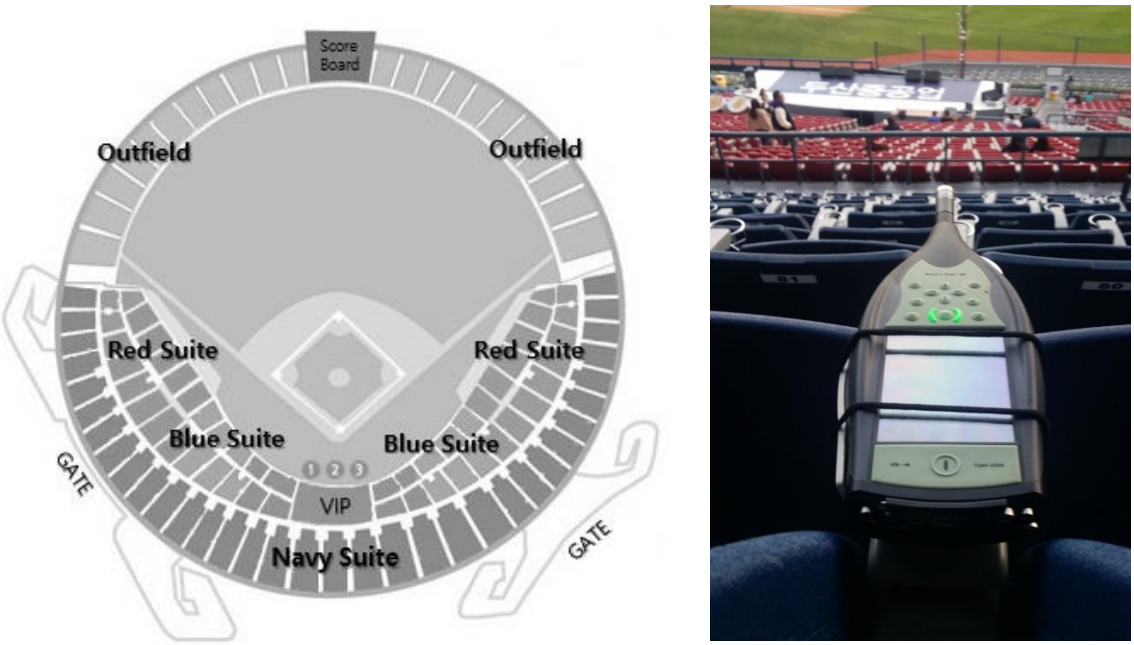

(**a**) (**b**)

Figure 1. Condition of the baseball stadium and measurement of noise level in the study. (a): Seating chart for the Seoul Complex Sports Baseball Stadium. The stadium is divided into four seating sections or suites, red, blue, navy, and outfield, where noise levels were measured in the study. Two small spaces in front of the left and right red sections are the cheerleader locations for each team. (b): A screen shot of noise measurement using sound level meters fixed on armrests while facing the ground of the stadium.

2.2. *Measurement of Noise Level*

A sound level meter (Type #2250, Bruel & Kjær, Nærum, Denmark), coupled with a ½-inch free field microphone (Type #4189, Bruel & Kjær, Nærum, Denmark), was used to measure the intensity of the noise level in the stadium from 20 Hz to 20 kHz, which is the audible frequency range of the human ear. The sound level meter has been developed to specifically measure environmental noise and the standard of the International Electrotechnical Commission (IEC) 61672-1 Class 1, IEC 60651 Type 1 was applied. The system was fixed on the armrest of each seating section, facing the ground of the stadium. Because we needed consistent measurements several times at the same spot while protecting the meters from being touched by spectators, we fixed the instruments at the armrest to ensure the least movement. To better understand the noise level measured in the study, we provide a screen shot of measurement condition in the right panel of Figure 1. After calibration, the system continually recorded from the beginning to the end of each game and it was analyzed via 16 measurements (4 games×4 sections, e.g., red, blue, navy, and outfield). The process took 3 hours, 42 minutes, and 17 seconds on average per game.

2.3. *Statistical Analysis*

The statistical analysis was performed using SPSS software (Ver. 20, IBM Co., Armonk, NY, USA). To compare a significant difference in overall noise levels across the four seating sections, a one-way analysis of variance (ANOVA) was conducted for LAeq, LAFmax, LAFmin, and LCpeak, although the decibel unit was a nonlinear scale of logarithmic scale. In addition, ANOVA with repeated measurements for Z-weighted analysis was also used to confirm the main effect for the distinctive frequency characteristics of noise in the baseball stadium. If necessary, Bonferroni corrections were applied for multiple comparisons. The criterion used for statistical significance in the study was $p < 0.05$.

3. Results

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3.1. Analysis of Noise Level: A- and C-weighted

ANOVA confirmed a significant difference in noise levels for the different seating sections with LAeq analysis [$F(3, 15) = 11.820$, $p = 0.001$]. The noise levels of both the red (mean: 94 dBA, SD: 2.10) and navy sections (mean: 91.9 dBA, SD: 0.95) were statistically higher than the level of the outfield (mean: 87.1 dBA, SD: 1.52) (see Figure 2 (a)). This 4.8-6.9 dB difference means that spectators of the red section could adhere to hearing guidelines by reducing their time watching the game from 4 hours to only 1 hour, if applying the 85 dB rule with a 3-dB exchange rate. Although the noise level of the blue section (mean: 90.7 dBA, SD: 0.45) did not significantly differ from that of the other three sections, its values were 3-dB lower than the red section and 3-dB higher than the outfield.

There was no statistically significant difference in noise level for the seating sections in LAFmax [$F(3, 15) = 1.117$, $p = 0.388$], LAFmin [$F(3, 15) = 0.296$, $p = 0.827$], and LCpeak [$F(3, 15) = 0.464$, $p = 0.714$]. For the LAFmax analysis, the level of the red section (mean: 116.5 dBA, SD: 2.45) was higher than that of the navy section (mean: 115.4 dBA, SD: 1.97), which in turn was higher than that of the blue section (mean: 114.8 dBA, SD: 3.03) and the outfield section (mean: 113.5 dBA, SD: 1.43). Although there was only a 1-dB difference across the sections, such a difference should not be overlooked at very high noise levels (Figure 2-(d)). In the LAFmin analysis, the navy section showed the highest level (mean: 62.8 dBA, SD: 1.43). The level of the red section (mean: 62.4 dBA, SD: 4.47) was higher than that for either the outfield section (mean: 61.7 dBA, SD: 0.82) or the blue section (mean: 60.5 dBA, SD: 1.48) (Figure 2-(c)). For the LCpeak, the C-weighted peak analysis of the four seating sections, the red section showed the highest noise level (mean: 130 dBA, SD: 1.76), followed by blue (mean: 129.3 dBA, SD: 3.75), navy (mean: 129 dBA, SD: 2.29), and outfield (mean: 127.8 dBA, SD: 3.47) (Figure 2-(b)).

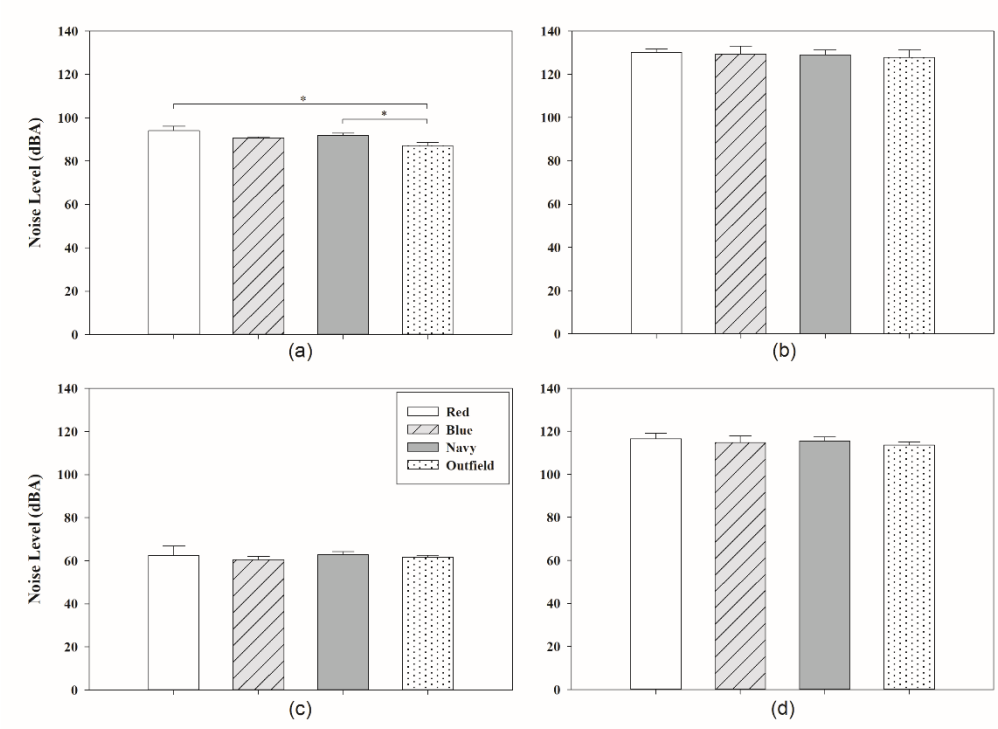

Figure 2. Average noise levels of LAeq (a), LCpeak (b), LAFmin (c), LAFmax (d), and as a function of the four seating sections that were studied. Significant differences in the noise levels (i.e., red vs. outfield and navy vs. outfield in the LAeq analysis) are marked with asterisks (* $p < 0.05$).

3.2. Noise Analysis of Distributed Frequency: Z-weighted

With no frequency weighting, the LZeq analysis showed a significant main effect for the four different seating sections [$F(3, 33) = 29.451$, $p < 0.001$] and for measured frequencies between 0.02 and

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20 kHz as the audible frequency range of the human ear [F(10, 33) = 112.012, $p < 0.001$]. The red (mean: 73.7 dBA, SD: 0.51) and navy (mean: 73 dBA, SD: 0.42) sections had a higher level than the blue (mean: 70.6 dBA, SD: 0.73) and outfield sections (mean: 66 dBA, SD: 0.73); the red section, the highest level, was 7.7 dB higher than the level of the outfield. Noise levels between 0.02 and 8 kHz were approximately 20-dB higher than those above frequencies of 8 kHz. However, a significant interaction was not seen between the different types of sections and their frequency [F(30,33) = 1.083, $p = 0.410$] (solid lines in Figure 3).

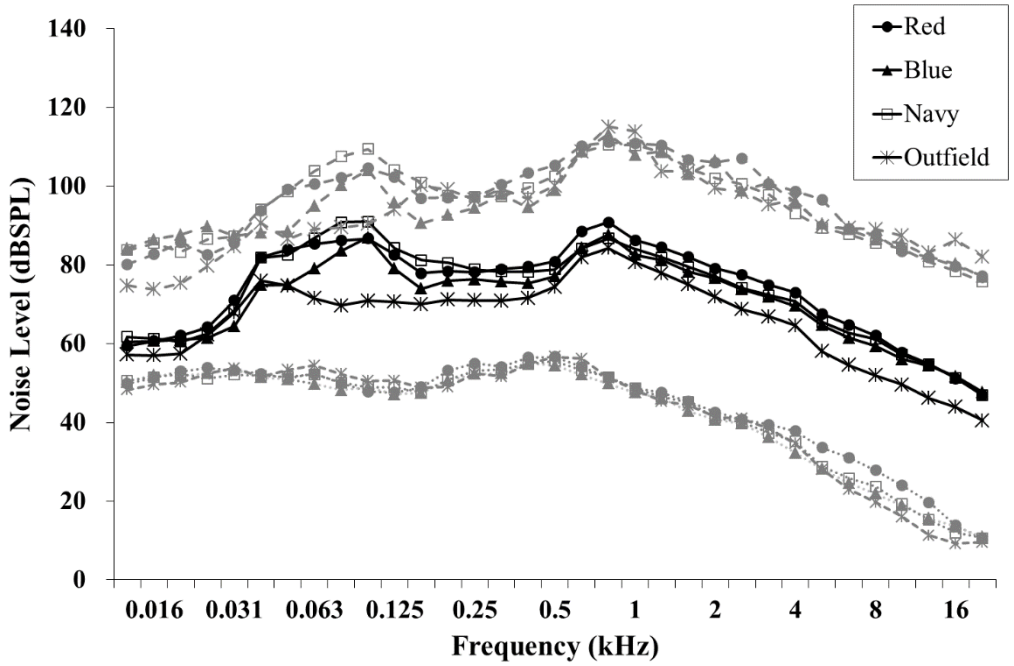

Figure 3. Average noise levels of the four seating sections as a function of of the audible frequency range in the human ear : a solid line for LZeq, a thick dashed line for LZFmax, and a light dashed line for LZFmin. Generally, the levels between 0.05 and 1 kHz were significantly higher than other frequencies, but they abruptly decreased above 1 kHz. Although the values of LZFmin were not substantially different in the four sections across the frequencies, the red and navy sections were distinguishably higher level than the outfield section in LZeq.

For the LZFmax analysis, there was no significant difference in the seating sections [F (3,33) = 1.841, $p = 0.159$], but a significant difference was found in frequency [F(10,33) = 34.748, $p < 0.001$]. The noise levels between 0.032 and 8 kHz were approximately 16-dB higher than those either below 0.032 or above 8 kHz. This range represents a similar frequency to the speech frequency of human beings, which is very important for communication (i.e., 0.1 – 8 kHz). However, no significant interaction was seen between seating sections and frequency [F(30,33) = 1.253, $p = 0.263$] (thick dashed lines in Figure 3). Notably, the LZFmin analysis showed a significant difference for the seating sections [F(3,33) = 3.144, p = 0.038]. The noise level of the red section (mean: 44.3 dBA, SD: 0.42) was higher than that of the blue section (mean: 42.3 dBA, SD: 0.59). In addition, there was a significant difference in the frequency [F(10,33) = 293.068, $p < 0.001$]. The noise levels in the low frequency below 1 kHz were approximately 25-dB higher than those above 1 kHz, implying that the noise in baseball stadiums has low frequencies in general. There was no interaction between the seating section and the frequency [F(30,33) = 0.853, $p = 0.668$] (light dashed lines in Figure 3).

Part 2: Survey Analysis for Awareness of Noise Exposure

2. Materials and Methods

2.1. Characteristics of Baseball Stadiums

A survey designed to target various age groups of baseball fans was adapted from survey items used by Chung et al.[17] and Lee et al.[16], which explored people's awareness related to non-occupational noise exposure and the negative effect on hearing. Its construct and content validities were verified as highly correlated in the previous papers.

In addition to demographic data for age and gender, the survey collected 1) personal preferences of people who attend a baseball game, such as selection of seating, cheering tools, and noise level of cheering (9 questions); 2) directed questions toward specific hearing issues, such as personal experience of hearing problems (3 questions); and 3) questions regarding methods of hearing protection (4 questions). The sixteen questions, including 3 sub-questions, were fully developed after consulting two professionals in the field. The survey format was multichotomous for ease in completion. With regard to reliability, its internal consistency was quite high; the value of the coefficient alpha (Cronbach's α) was 0.89. Table 1 depicts the survey items and their responses.

2.2. Data Collection

The survey was administered anonymously, using either an offline or online method. In the offline method, spectators at a baseball game were directly asked the questions by a researcher at two-hours before the game began. For the online method, the official website of two baseball teams using the Seoul Complex Sports Baseball Stadium as home ground (i.e., the Doosan Bears and LG Twins) was chosen. For three weeks, a pop-up survey was presented on the website because of its large congruence of visitors and its reputation as a leading authority for baseball fans.

2.3. Participants

A total of 688 surveys (300 offline and 368 online) were analyzed after excluding participants who withdrew from the survey and incomplete surveys. Of the total respondents, people in their 20s (42.81%, 152 female and 134 male) constituted the majority of the respondents, followed by people in their 30s (28.14%, 84 female and 104 male), teens (12.28%, 40 female and 42 males), 40s (11.38%, 28 female and 48 male), 50s (4.79%, 12 females and 20 males), and 60s (0.6%, 2 female and 2 male). In addition, the total population consisted of 318 females (47.60%) and 350 males (52.40%), with an average age of 29.63 years (ranging from 13 to 65).

Informed consent was obtained only for the offline participants because of the inherent and voluntary nature of completing an anonymous web-based survey distributed using the online method (formally waived by the ethics committee). The offline participants signed a written informed consent form. Among them, participants who were under 16 obtained the consent form via their parents. The experimental procedure was reviewed and approved by the Institutional Review Board of Hallym University.

3. Results

Of the total respondents, 63% attend a baseball game 1~2 times per month (Item #1 of Table 1), and half of the respondents attend with friends due to their love of baseball (Items #3 and #4). Further, 70% of the respondents reported sitting in either the red or the navy section, usually the one closer to the cheerleaders with a good view of the game (Item #5). The majority of respondents watched the game from beginning to end (or to the 9th inning) (Item #6). Regarding noise levels in the baseball stadium, 40% reported that they do not mind it, and 32% tolerated the noise although it was loud (Item #7). They usually used clapping (59%) and thundersticks (35%) as cheering tools (Item #8). During the game, the majority of the respondents indicated that loud noise such as shouting and cheering was not significant enough to consider wearing earplugs (Items #9 and #10), noting that it was not a necessity (37%) or that it would make them lose interest in the game (35%). Nonetheless, one-third of the total respondents had some trouble in their daily lives after watching a baseball game in the stadium (Item #11). For example, they could not hear clear speech for a while (33%) and had a

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231 headache (28%). Finally, 63% of the respondents agreed that an announcement was needed to explain
232 the loud noise in the stadium and the possible use of hearing protection (Item #12).

233 **Table 1.** Summary of results for the 15-questions except for Item 13. Boldface highlights answers given
234 by more than 30% of the total respondents.

Item Number	Ranking Order				
1. How many times do you go to a baseball stadium on average per month?	**1~2 times (63%)**	3~5 times (25%)	6~8 times (6%)	8 times or more (6%)	
2. When did you first see a baseball game in a stadium?	**20s (47%)**	10s (26%)	Before teen years (17%)	30s (7%)	40s (3%)
3. Who do you go to a baseball stadium with?	**Friends (69%)**	Family (20%)	Members of baseball club (9%)	Other (2%)	
4. Why do you like to watch a baseball game?	**Like the baseball (53%)**	Like cheering culture (19%)	Relieve stress (17%)	Other (8%)	Promote friendship (3%)
5. Which section do you usually prefer to sit in at the stadium?	**Red (38%)**	**Navy (32%)**	Blue (19%)	Outfield (9%)	Other (2%)
5-1. Why do you prefer the section you selected?	**Closer to cheerleaders (41%)**	**Want a good view of the game (32%)**	To see the game comfortably (13%)	Other (8%)	Cheaper ticket price (6%)
6. How long do you stay at the baseball game?	**The 9th inning (from beginning to the end) (82%)**	Others (8%)	The 8th inning (7%)	Leave when my team is losing the game (3%)	The 7th inning (1%)
7. How loud do you think the cheering and shouting noise in the stadium is?	**Not considered (40%)**	**Loud enough, but tolerate (32%)**	Comfortable (24%)	Too loud to tolerate (3%)	Low or soft (1%)
8. Which cheering tool do you mostly use?	**Clapping by striking palms together (59%)**	**Thunderstick s (35%)**	Horn such as *vuvuzela* (6%)	Other (0%)	
9. When feeling uncomfortable due to loud cheering and shouting noise, what do you do?	**Nothing (85%)**	Move to another seat (9%)	Other (4%)	Wear earplugs (2%)	
10. If your ears don't feel good due	**No, would**	Yes, would			

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to loud cheering and shouting noise, would you consider wearing earplugs?	**not wear them (92%)**	wear them (8%)			
10-1. Why don't you consider wearing earplugs when you have trouble due to loud noise during a baseball game?	**Don't feel the need (37%)**	**Will lose half my interest in the game (35%)**	Discomfort and stuffy to wear (19%)	Inconvenience of purchase (5%)	Lack of information about earplugs (4%)
11. Have you had any negative symptoms in your daily life after watching a baseball game in the stadium?	**No (89%)**	Yes (11%)			
11-1. Which symptoms did you have?	**Not hearing clear speech for a while (33%)**	Headache (28%)	Muffled ear and otalgia (18%)	Tinnitus (15%)	
12. Do you think that an announcement is needed to explain possible loud noise in the stadium and available hearing protection during break times?	**Yes, need it (34%)**	No, not necessary (25%)	Yes, need it a little (20%)	I do not know (12%)	Yes, positively necessary (9%)

Notably, only 2% of the respondents reported a personal intention to use earplugs at a future baseball game that had loud noise (Item #9 of Table 1). However, this number increased when the respondents were encouraged by a medical professional (79%) or were made aware of the potential for permanent hearing loss (74%) (see Table 2). When asked about receiving information from booklets, 40% responded positively and 40% responded negatively. Furthermore, a respective 63% and 67% of the respondents were unlikely to be affected by information on TV or the perception of peers who might wear earplugs in loud situations.

Table 2. Summary of results for Question #13 regarding factors likely to influence the use of hearing protection. Boldface highlights the answers given by more than 30% of the total respondents.

Occasion	Very likely	Somewhat likely	Not too likely	Not likely at all	Total Responses
A doctor or nurse telling you that you should wear earplugs to protect your hearing	**232 (35%)**	**292 (44%)**	84 (13%)	60 (8%)	668 (100%)
Knowing that even limited exposure to very loud noise can permanently damage your hearing	180 (27%)	**314 (47%)**	130 (19%)	44 (7%)	668 (100%)
Reading a booklet that says prevention of hearing loss is best	18 (3%)	**270 (40%)**	**270 (40%)**	110 (17%)	668 (100%)

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way to keep good hearing

Learning about earplugs on TV	24 (4%)	**218 (33%)**	**292 (44%)**	134 (19%)	668 (100%)
Seeing your friends wear earplugs in very loud conditions	38 (6%)	188 (28%)	**290 (43%)**	152 (23%)	668 (100%)

4. Discussion

It is well-acknowledged that noise-induced hearing loss is preventable. Without effective prevention, the quality of life among affected people can decline, and health-care costs for society can increase [18]. This fact is demonstrated by non-occupational noise-induced hearing loss in the public due to frequent exposure to high noise levels [19]. This study measured the intensity of noise levels during a baseball game and analyzed the issue of hearing loss due to recreational noise exposure at baseball games. The results of this study indicated that the LAeq at 14 measurements for approximately four hours of each game was 91.7 dBA. This value was 7-dB higher than that reported by England et al., who found an average 84.6 dBA at a basketball game [14]. However, it was slightly lower than the average result of Morris et al., who reported a range of noise level between 90 and 95 dBA in a basketball stadium [7]. Noise levels at these sporting events are high enough to exceed acceptable intensity levels when compared to the national workplace noise exposure standard [2]. If applying a rule of 85 dB LAeq for 8 hours with a 3-dB exchange rate, spectators should only be exposed to the high noise level of 91.7 dB in the baseball stadium for less than 2 hours. However, as previously mentioned, the average game time was approximately four hours. Thus, if the duration of noise exposure could not be reduced by shortening the game time, the stadium should announce the level of noise, possible hearing problems, and the availability of hearing protection devices to baseball game spectators (in Item #12, 63% of respondents agreed that this information was necessary).

When summarized, the LCpeak average for these sporting events indicated that the baseball game at 129.4 dB had a 3-dB higher level than the basketball game at 126.3 dB [7], producing potential damage to hearing. Without awareness of noise exposure limits, many spectators who have already been exposed to intense noise over the course of the day in their jobs and then later attend sporting events may be putting themselves at risk of permanent noise-induced hearing loss [14].

In Korea, baseball stadiums usually do not have roofs, meaning that the noise level depends on weather conditions [20]. For example, many spectators left the stadium when it began to rain during the four measurements in our study. As a result, the noise levels of these games were lower than those played on days with good weather. In addition, compared to the games played on weekdays, those on weekends had a larger group of spectators, resulting in increased noise levels and a stronger risk of potential hearing damage. In sum, if the weather is favorable on the weekend, more spectators attend games and thus are exposed to higher noise levels in the stadium.

Based on our analysis of the survey, many baseball fans have attended games one to two times per month since their 20s because they enjoy baseball. One-third of the total respondents recognized that the noise level produced by shouting and cheering during the game is very loud; however, the majority of respondents did not know how to prevent a hearing problem. Furthermore, noise occurring at the baseball games produced higher levels in the speech frequency range between 0.1 and 8 kHz [21], which was also supported by our survey results; 89% of the respondents had a negative communicative experience in their daily lives after watching the game, and 33% also reported hearing unclear speech. Thus, if people habitually and routinely attend games while being exposed to high noise levels and have no chance to learn about effective protection methods for

hearing, their hearing damage will become a much more serious problem, both socially and economically [17].

It is desirable to make an announcement about recreational noise exposure and its negative effect on hearing at sporting events, as supported by respondents in our study. Several research efforts have shown the positive impact of hearing conservation programs on behavior modification in young adults [18, 22]. The highly substantial positive behavioral response to a "doctor or nurse telling you that you should wear earplugs" (Item #13) indicates that professionals have an opportunity to influence the public's hearing behavior by providing education about hearing protection at many levels of society.

5. Conclusions

This study shows that the noise level in baseball stadiums is high enough to cause possible hearing damage and/or tinnitus if spectators frequently attend baseball games. When applying a rule of 85 dB LAeq for 8 hours with a 3 dB exchange rate, the average level of 91.7 dBA only allows spectators to watch a game for about 2 hours. In particular, the red and navy sections had a significantly high noise level. Of further concern is that people who watch a game in a stadium do not understand the severity of the noise levels there and are not given a chance to use earplugs. However, many fans can be persuaded to wear hearing protection if they receive adequate education and counseling. We expect these results to inform the public about the need for education on injurious noise exposure during leisure activities such as baseball games. Education on hearing conservation can be implemented on many fronts in society to periodically educate youth about hearing health.

Abbreviations

ANOVA: Analysis of variance; IEC: International Electrotechnical Commission; LAeq: A-weighting equivalent level occurring during the measurement time; LAFmax: the highest level of environmental noise measured by A- and Fast-time weighting; LAFmin: the lowest level of environmental noise measured by A- and Fast-time weighting; LCpeak: the highest peak level measured by C-weighting; LZeq: Z-weighting equivalent level occurring during the measurement time; LZFmax: the highest level of environmental noise measured by Z- and Fast-time weighting; LZFmin: the lowest level of environmental noise measured by Z- and Fast-time weighting; WHO: World Health Organization

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