Hearing loss in steelband musicians

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OBJECTIVE: To determine the difference in hearing between a group of steelband musicians (pannists) and a control group.

DESIGN, SETTINGS, AND SUBJECTS: We conducted a controlled cross-sectional pilot study consisting of 29 steelpan players and 30 control subjects from a steelpan orchestra (steelband) in the Otolaryngology Department of the Eric Williams Medical Sciences Complex.

RESULTS: Significantly more steelpan players had a hearing loss than the control subjects at 3000 Hz, 4000 Hz, and 6000 Hz (P < 0.01). χ² testing for trend demonstrated that the longer a steelpan player played his instrument the greater the hearing loss. CONCLUSION: These results indicate that pannists suffer permanent auditory damage from high-intensity sound levels and that preventative measures are required to prevent this hearing loss, particularly in younger players. (Otolaryngol Head Neck Surg 2004;131:461-5.)

The musical instrument now known as the “steelpan” was invented on the island of Trinidad, in the West Indies. Highly talented and enterprising musicians discovered that they could alter the tonal qualities of the base of steel drums that were usually used for transporting oil. The basic technique, which is still in use today, consists of heating the steel base and then, by hammering, demarcating it into different segments with different shapes, each segment with its own tone. As with other musical instruments, the tuners have become highly skilled in creating instruments (pans) of varying tonal characteristics. Based on their fundamental frequencies, the pans are now designated as tenor, cello, bass, etc., terminology obviously borrowed from Western musicology.

Frequency ranges of the various pans were studied and are detailed in Table 1. In 1992, the Trinidad and Tobago Bureau of Standards issued the first part of its standardization of the steelpan. From the very beginning, steel pans have been played in groups as orchestras (steelbands) that might be accompanied by other instruments such as drums or, equally intriguing, bits of “iron.” This all comes together to generate a phenomenon that has become the musical symbol of the Caribbean.

The steelpan is now recognized as the only truly new, musical instrument invented in the twentieth century. The instrument has progressed from the backyards of Trinidad to the stages of Carnegie Hall and the White House.

In the dual-island nation of Trinidad and Tobago, the Carnival season begins in early January and climaxes on the 2 days before Ash Wednesday, in a brilliantly costumed extravaganza, danced to the beats of the calypso and steelbands. An integral part of the Carnival celebrations, is the “Panorama” competition in which the steelbands compete for the accolade of being the best in the country. In preparation for this event, the musicians practice intensely in 6- to 8-hour sessions daily for about 3 months. Additionally, the steelband has become a generally popular orchestral form that is now played year-round. During the sessions of practice and performance the players are exposed to very high intensities of sound that has the potential for damage to the auditory system.

Aziz, as quoted by Kuruvilla, was the first to document that steelband musicians develop hearing impairment. His findings were later confirmed by Griffiths and Samaroo.

We have, therefore, undertaken a longitudinal controlled study of the hearing of steelband musicians, the objective of which was to assess the effect of long-term exposure of the players to the ambient noise of the orchestra and to compare our findings with those of previous authors. In this paper we present the preliminary analysis of the first phase of our investigation.

MATERIALS AND METHODS

This study was performed in accordance with the guidelines for clinical research defined by the University of the West Indies. A steelband (Exodus Steel Orchestra) that had easy access to the Otolaryngology Department, Tufts University School of Medicine, Boston, MA (Dr Karmody); and the Department of Preventative Medicine, Faculty of Medical Sciences, University of the West Indies, Trinidad, West Indies (Dr Juman); the Department of Otolaryngology, Faculty of Medical Sciences, University of the West Indies, Eric Williams Medical Sciences Complex, Mt. Hope, Trinidad and Tobago, West Indies.

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Clinic was approached and, of the 32 members, usually known as “pannists,” 31 volunteered to take part in the study. One of the volunteers defaulted and 1 was excluded because of severe hearing loss, leaving a total of 29 participants.

Participants were asked to complete a questionnaire detailing their basic demographics, current or previous ear problems, the length of time that they had played in a steelband, their type of instrument, and how long they had played it.

Our control group consisted of 30 age-matched volunteers without a history of playing the steelpan or any ear problems. These also completed questionnaires detailing their basic demographics.

All 59 volunteers underwent a thorough clinical otological examination. No significant otopathology was detected, and therefore, none were excluded and all musicians and controls attended the audiometry sessions. The relevant demographics of each group are summarized in Table 2.

### Results

#### Comparison of Hearing Between Steelband Players and Control Subjects

Normal hearing was defined as hearing thresholds of less than 20 db, mild hearing loss as between 20 and 35 db, moderate loss as between 35 and 50 db, and severe loss as over 50 db. The mean threshold at each frequency was calculated by averaging the combined thresholds of both ears at that frequency. The thresholds at 250, 500, and 1000 Hz, were combined and averaged to collectively represent the low-frequency pure tones (LFPT) and those at 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, and 8000 Hz were similarly combined to represent the high-frequency pure tones (HFPT).

Using the χ² test, there were statistically significant elevation of the thresholds of the musicians compared with the controls at the individual frequencies of 2000 Hz (P < 0.02), 3000 Hz, 4000 Hz, and 6000 Hz (P < 0.001). Similarly, there were statistically significant differences in the HFPTs (P < 0.001), but no differences in the LFPTs.

Using logistic regression to control for possibly confounding age factors, there were still statistically significant differences between the players and controls at 2000, 3000, and 4000 Hz (P < 0.01) and 6000 Hz (P < 0.04) and HFPT (P < 0.01), as summarized in Table 3.

#### Comparison of Hearing Between the Groups at Different Ages

There were 8 steelband players and 14 control subjects who were less than 30 years of age and no differ-

### Table 1. Frequencies of steel pans (modified from Kronman1)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Frequency spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bass</td>
<td>63-330 Hz</td>
</tr>
<tr>
<td>Cello</td>
<td>110-370 Hz</td>
</tr>
<tr>
<td>Guitar</td>
<td>140-415 Hz</td>
</tr>
<tr>
<td>Double second</td>
<td>175-1105 Hz</td>
</tr>
<tr>
<td>Tenor</td>
<td>175-1450 Hz</td>
</tr>
</tbody>
</table>

### Table 2. Demographic data on steelband players and control groups

<table>
<thead>
<tr>
<th></th>
<th>Steelband players</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>37.5</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>18-60</td>
</tr>
<tr>
<td>Male:Female</td>
<td></td>
<td>23.6:11.9</td>
</tr>
</tbody>
</table>

Kjaer Model 22311, Denmark) with a filter (Brul & Kjaer Model 1625).

The A-weighting network in a sound level meter makes the meter less sensitive to low frequency stimuli thereby mirroring the lesser sensitivity of the human ear to the same low frequency sounds. Measurements were made on 2 consecutive days. The recorded sound pressure levels are shown in Figure 1. Readings were obtained on both days at the 8 positions shown in Figure 1. Positions 1-4 were around the periphery of the band within 12 inches of the players; positions 5-8 were around the centrally placed “rhythm section.”

#### Results

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Using logistic regression to control for possibly confounding age factors, there were still statistically significant differences between the players and controls at 2000, 3000, and 4000 Hz (P < 0.01) and 6000 Hz (P < 0.04) and HFPT (P < 0.01), as summarized in Table 3.

**Comparison of Hearing Between the Groups at Different Ages**

There were 8 steelband players and 14 control subjects who were less than 30 years of age and no differ-
ence was found in the hearing between these groups. Similarly, no differences were detected in the 31-40-year age groups in which there were 10 steelbandsmen and 12 control subjects. In the group of subjects 40 years of age, however, in which there were 11 steelbandsmen and 4 control subjects, there were statistically significant differences at 3000 Hz, 4000 Hz, and 6000 Hz ($P < 0.001$) and collectively in the HFPTs ($P < 0.002$).

**Comparison of Hearing Between the Different Sections of the Steelband**

The number of players in each section of the steelband were: tenor 8 players, bass 6, cello 6, and percussion 9 players. In the HFPT, 6 of the 9 (66%) percussionists in the rhythm section had some degree of loss, whereas, of the remaining 20 players in the other sections of the band, only 7 had hearing losses. Using the $\chi^2$ test, the differences between the percussionists and the rest of the band was statistically significant ($P < 0.02$). When the analysis was controlled for age, however, the significance was lost.

### Table 3. Abnormal hearing

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Steelband players (n = 29)</th>
<th>Controls (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>250</td>
<td>3 (10)</td>
<td>0</td>
</tr>
<tr>
<td>500</td>
<td>1 (3)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>1000</td>
<td>5 (17)</td>
<td>0</td>
</tr>
<tr>
<td>2000*</td>
<td>10 (35)</td>
<td>0</td>
</tr>
<tr>
<td>3000*</td>
<td>12 (41)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>4000*</td>
<td>12 (41)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>6000*</td>
<td>15 (52)</td>
<td>6 (20)</td>
</tr>
<tr>
<td>8000</td>
<td>13 (45)</td>
<td>2 (7)</td>
</tr>
<tr>
<td>HFPT*</td>
<td>13 (45)</td>
<td>0</td>
</tr>
</tbody>
</table>

$HFPT$, high-frequency pure tones.

*Group difference significant after controlling for age.

### Table 4. Hearing loss vs. number of years playing the steelpan

<table>
<thead>
<tr>
<th>Years playing pan</th>
<th>Normal</th>
<th>Mild loss</th>
<th>Moderate loss</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 yr (n = 7)</td>
<td>7 (100%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10-19 yr (n = 10)</td>
<td>6 (60%)</td>
<td>3 (30%)</td>
<td>1 (10%)</td>
<td>0</td>
</tr>
<tr>
<td>20+ yr (n = 12)</td>
<td>3 (25%)</td>
<td>5 (42%)</td>
<td>3 (25%)</td>
<td>1 (8%)</td>
</tr>
</tbody>
</table>

$HFPT$, high-frequency pure tones; $LFPT$, low-frequency pure tones.

### Relationship Between the Length of Time Playing and Hearing Loss

None of the 7 who had played the steel instruments for less than 10 years had a hearing loss. Four of 10 (40%) who had played between 10 and 19 years had hearing losses, and 9 of 12 (66%) who had played for more than 20 years had hearing losses.

A $\chi^2$ test for trend demonstrated significant trends at 2000 Hz ($P < 0.04$), 3000 and 4000 Hz ($P < 0.05$), 6000 Hz ($P < 0.03$), 8000 Hz ($P < 0.02$), and HFPT ($P < 0.002$). The implication was obvious that the longer one played the steelpan, the greater the hearing loss (Table 4).

### DISCUSSION

Since the first reports of acoustic trauma from rock and roll music there has been increasing awareness of the effects of loud noise on the hearing of musicians. Westmore and Eversden found the sound pressure levels at different points in a symphony orchestra to range from 90 dBA for 3.51 hours to 110 dBA and above for shorter intervals. They also found that, in the musicians, 23 of 68 ears tested had mild to slightly moderate noise-induced hearing losses centered around 4000 Hz. The woodwind players were the most affected (13 of 28). These findings were confirmed by Axelsson and Lindgren and Teie but were only partially supported by the study of Kahari et al. Recently, Steuer et al demonstrated that even choir singers were at risk for noise-induced hearing loss. A study by Lebo et al found that even audiences are risk. These authors found the sound pressure levels in the concert halls of rock and roll and symphony concerts to be substantially above safe levels. Meyer-Bisch and Tin and Lim demonstrated the dangers of personal cassette players and of discotheques and rock and roll concerts to the...
audiences, but Axelsson et al\(^\text{18}\) in a long-term follow-up study, found comparatively little progression of high-frequency hearing losses in rock and roll musicians over a period of 26 years. The picture of noise-induced hearing loss in musicians, therefore, remains somewhat confusing.

Kuruvilla\(^\text{4}\) reported on the investigation by Aziz who, in a point prevalence audiometric study, found that 20 of 30 steelbandsmen had elevated threshold shifts. Griffiths and Samaroo,\(^\text{5}\) however, reported that of 50 male pannists aged 16 to 58 years, 36 (72\%) had hearing losses in the 3000 to 6000 Hz range and 36 (72\%) complained of tinnitus. They also found the percussionists to be most affected. In general, however, the findings of the 3 studies are basically similar in that they demonstrate the potential for the intensity of noise generated in a steelband to cause sensorineural hearing loss in the audiometric frequencies that are characteristically affected in noise trauma (2000-6000 Hz). The noise level at the core of the band is consistently above 100 dBA (Fig 1). This is comparable to the level 2 to 4 meters from center stage of a rock and roll band.\(^\text{19}\) It also far exceeds the recommended exposure for factory noise, which is currently set by the U.S. Occupational Safety and Health Administration (OSHA) at 90 dBA.\(^\text{20}\) The American Academy of Otolaryngology–Head and Neck Surgery and the American Academy of Audiology strongly recommend that this figure be reduced to 85 dBA for an 8-hour work day.

Prevention of hearing loss among musicians continues to be an elusive goal. Dampening of sound levels while still allowing for the fine appreciation and monitoring of musical tones seems to be fundamentally contradictory concepts. It is therefore not surprising that, in general, musicians have been reluctant to use ear protectors. Steelbandmen, however, are greatly in need of some type of protection if they are to continue to contribute to this musical form for more than 20 years. Simple strategies such as break periods during practice and playing on alternate days might substantially reduce the risks. Recent technological advances in filtering mechanisms might be helpful.\(^\text{21}\) Additionally scientists at the European Commission for Concerted Action for Protection against Noise have suggested that magnesium, superoxide dismutase, desferrioxamine, manitol, and a glial line-derived neutropic factor and heat shock proteins all provide some form of protection against damage by loud noise.\(^\text{22}\) The efficacy of these substances is still under investigation.

At the present time we are concerned about the younger generation of steelband players, some of whom are beginning at approximately 10 years of age.

We earnestly hope that a happy medium can be attained that would allow free expression of the considerable talents of these youths while protecting the sense organ that is fundamental to their achievements.

**CONCLUSIONS**

This study, along with other studies, clearly demonstrates that steelband players are at a high risk of developing hearing losses, which is directly dependent on the length of time of exposure. Although further research is necessary, preventive measures are strongly recommended to provide protection while still allowing musical expression.

We would like to thank the Campus Research Committee of the University of the West Indies (St. Augustine) for funding this research. We would also like to thank Ainsworth Mohammed, the manager of Exodus steelband, and all the volunteers involved in this study. Many thanks to Mary Slinger, Fazil Muddeen, and Lystra James for their invaluable contribution to this project.

**REFERENCES**