Short Communication

Evaluation of Musical Conductors' Exposure to Noise

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This article presents the results of a case study on the evaluation of occupational noise exposures among a musical conductor in a musical hall (party – center). A calibrated noise dosimeter was used to measure the personal exposure of a music teacher/conductor for 8 hours over two days of rehearsal involving 90 players. Results showed that noise exposure levels were much higher than the permissible levels regulated at 85dBA/8hr by NIOSH. The first day of measurements recorded the highest exposure levels (91 dBA). Several factors contributed to these results, such as the number of players, the types of instruments used, and the activities. Several noise control measures were recommended to address this situation.

1. Introduction

Noise is defined as any unwanted sound. Exposure to noise has been found to result in personal and social aspects including annoyance, stress, anger, distraction, poor speech intelligibility, anxiety, loss of productivity, tinnitus, and hearing loss[1].

Several studies have investigated the occupational exposure to noise among many workers from different work sectors around the world, including industries, offices, and schools. However, musical conductors have rarely been investigated for their noise exposures, even though their musical activities are responsible for producing very loud noise. For instance, a study was conducted on 18 music teachers at a public school; results showed that 78% of them were exposed to noise levels higher than 85dBA/8hr[2].

Another assessment found that one third of 17 musical instructors were at risk of exposure to high levels of noise that exceeded the limits of 85 dBA. It was found that a number of activities contributed to these high daily noise levels, including group rehearsal, performance, and personal practice sessions[3].

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Around nine music teachers were involved in another study and were found to be exposed to unacceptable occupational noise levels during normal working days in schools. Several factors associated with their exposures involved the types of instruments they play, room acoustics (e.g., reverberation time), room design, and number of students[4].

The present study evaluated the occupational noise exposure level among a conductor in a musical rehearsal hall during a full shift for two days. It also compared the results with the permitted occupational noise exposure levels by NIOSH (85 dBA/8 hr a day)[5] and investigated the main factors contributing to the noise exposure results.

2. Method

2.1. Study Site and Subject

This study was conducted in a musical rehearsal hall at a medium-sized concert center (area = 800 $m^{2;}$ volume = 4800 m^3). Measurements of noise exposure levels were taken for a male musical conductor at that musical rehearsal hall for two days during periods of rehearsal. The subject voluntarily participated in this study and provided verbal consent for noise exposure monitoring. Since the study only involved non-invasive environmental measurements, formal ethics approval was not deemed necessary. Moreover, to maintain confidentiality, no personally identifiable information was collected. The subject's responses were anonymized before analysis.

2.2. Physical Noise Measurements

a) Noise Exposure Level, dBA

A calibrated and fully recharged noise dosimeter (CEL-350 dBadge) was used to measure the equivalent noise level (L_{Aeq}, dBA) that the teacher was exposed to during the days of sampling. At the beginning of each day of sampling, the CEL-350 dBadge was attached to the subject's shoulder within his hearing zone and turned on for logging noise levels during the shift hours. At the end of each day, the dosimeter was removed from the subject's shoulder, turned off immediately, and then connected to our lab computer to upload the stored data through special software (CEL-350db). Results were analyzed and compared with the noise exposure limit of 85 dBA/8 hours a day as regulated by the National Institute of Occupational Health 'NIOSH'.

b) Daily Activity Log

The subject was asked to fill in a special daily logbook recording all musical rehearsal activities he performed during the days of sampling.

3. Results

Figures 1 and 2 show a variation in the noise L_{Aeq} per each hour of exposure on each day. L_{Aeq} on the first day ranged between 77 dBA at the first hour of the shift to 94 dBA almost at the last hour. In addition, the minimum noise exposure levels ranged between 65 dBA and 72 dBA, and the maximum levels ranged between 86 dBA and 105 dBA.

However, the average L_{Aeqs} on the second day ranged between 74 dBA at the first hour of the shift to 88 dBA at the last hour. What's more, the minimum levels ranged between 66 dBA and 69 dBA, and the maximum levels ranged between 80 dBA and 98 dBA. This comparison shows that the noise exposure levels on the second day were lower than those on the first day due to activities and loads as described in detail in the discussion part.

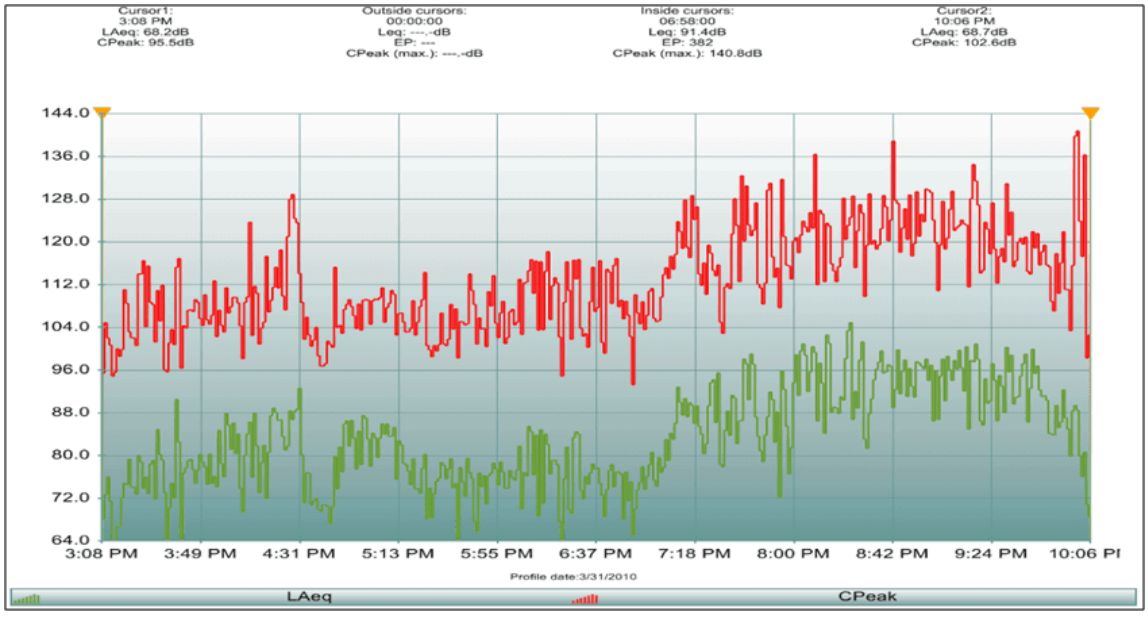

Figure 1. Measured L_{Aeq} and C_{Peak} of continuous exposure to noise for 7 hours on the first day for a musical conductor during a rehearsal session.

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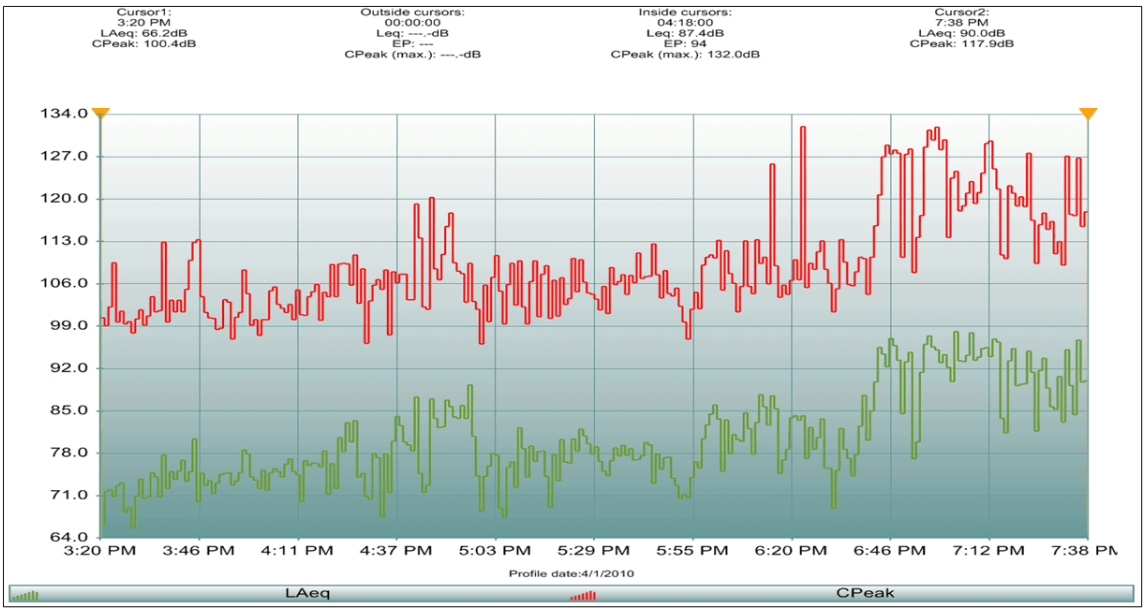

Figure 2. Measured L_{Aeq} and C_{Peak} of continuous exposure to noise for 4 hours on the second day for a musical conductor during a rehearsal session.

Table 1 shows that on the first day the subject was exposed to an average of 91 dBA for 8 hours, which was higher than the permissible exposure level of 85 dBA. However, the results of the second day showed that the subject was exposed to 85 dBA, which is equal to the permissible exposure level.

These results showed that on the first and the second day, the subject was exposed to an average noise level of 91 and 85 dBA respectively. Since these values represent a single measurement rather than an estimate with confidence intervals, we acknowledge this as a limitation. However, this serves as a preliminary step in validating our research hypothesis. Future studies will incorporate broader sampling and statistical analyses to enhance the robustness of the findings.

Day	Measured Lex, dBA		Calculated L_{ex}, dBA	Permitted L_{ex},8Hr/day, dBA (NIOSH)
1	L_{Aeq}	91.4	91	85
	$C._{Peak}$	140		
2	L_{Aeq}	87	85	
	$C._{Peak}$	132		

Table 1. Results of two days of noise exposure levels, dBA/8hr, for a musical conductor during rehearsal sessions in a music rehearsal hall at a concert center.

4. Discussion

The results of this investigation indicated differences between the two days of measuring.

On the first day, the equivalent noise exposure level was 91 dBA/8 hrs with a peak level of 140 dBA. This obtained value (91 dBA) is higher than the limit of the noise exposure level (85 dBA), which is in agreement with previous studies on noise exposure among musical teachers/instructors[2][3][4].

As shown in Table 2, there was a high oscillation in the noise levels during the last 3 hours (19:12 to 22:05) of the shift. The subject was exposed to equivalent noise levels that ranged between 89 and 94 dBA/1 hr. The activities logbook and observation data show that the reason for these high levels of noise was the high sound generated by the fully symphonic band that consisted of 90 musical players. In fact, the worker was setting up and walking around this musical band while they were playing the symphony. In addition, the maximum hourly noise levels ranged between 101 and 105 dBA during this activity.

On the other hand, the subject was exposed to lower levels of sound (76 – 81 dBA/1 hr) from 15:10 to 19:11 when there were only some room settings.

Day of Sampling	Duration (hour)	L_{Aeq}, dBA	Activities	Min, dBA	Max, dBA
1	15:08–16:08	77	Orchestra warming up	67	90
	16:09–17:09	81	Junior Brass – 4 players Junior Sax – 4 players	67	93
	17:10–18:10	76	Room set-up	66	86
	18:11–19:11	77	Drum rehearsal	65	93
	19:12–20:12	89	Full symphonic band (90 players)	72	101
	20:13–21:13	94		81	105
	21:14–22:05	90		69	101
2	15:20–16:20	74	Meeting only	66	80
	16:21–17:21	78	Small groups (3–4 players)	67	89
	17:22–18:22	79		66	88
	18:23–19:38	88	Concert youth band (30 players)	69	98

Table 2. Variations of a musical conductor noise dose per hour during the actual period of rehearsal for each day of measurement and the activities presented.

Moreover, noise exposure levels didn't exceed 81 dBA/1hr during the first three hours of this shift due to the activity of the orchestra and about 4 junior brass/sax players warming up.

On the contrary, the second day of measurements reflected a situation that was much quieter than the first day. On this day, the equivalent noise exposure level was only 85 dBA/8 hr, which is acceptable because it's lower than the limit noise exposure level in BC (86 dBA).

The fluctuations of noise exposure levels were very low during the first hour of the shift (15:20-16:20), in which the noise level was 74 dBA. This was a result of a minor activity, which was having a meeting only with some of the musical group. Since the musical bands started to play in small groups (3-4 players) from 16:21 to 18:22, a slight elevation in noise levels began to appear (Fig.2), and the subject was exposed to 78-79 dBA.

However, during the period from 19:30 to 21:30, the noise exposure levels rose very high. Therefore, our subject was exposed to 88 dBA because of the noise generated by 30 youth players of a concert band playing. These findings confirm the fact that they work directly with the sound source responsible for their own sound exposure. The types of musical instruments, the way to play them, the contemporary playing of more than one musical instrument (by teachers and students), as well as the type of music played, can produce sound exposure levels that can easily exceed the limits recommended by the standards, with a consequent risk for NIHL[3][6][7].

Moreover, previous studies also show that orchestral musicians often encounter loud music, leading to selective hearing loss, tinnitus, hyperacusis, and diplacusis. These issues can make it difficult to distinguish changes in pitch and intensity and can significantly affect musical perception. Tinnitus and hyperacusis are among the most common ear disorders in this population[8].

5. Conclusion

The present monitoring of occupational noise exposure for the selected subject (musical conductor) in the musical rehearsal hall showed clearly that very loud noise is generated when there is a large number of music players (90 players). This had resulted in the subject being exposed to more than 90 dBA/8hrs, which exceeded the limits of exposure on the first day. However, the noise exposure level on the second day wasn't higher than the standard due to the small musical rehearsal group.

Indeed, these case study findings suggest that the investigated musical conductor was at risk of occupational adverse health effects due to his exposure to high and unacceptable noise levels.

This case study suggests that music conductors may be exposed to high noise levels in their work, reflecting some agreement with previous similar field studies. However, as this research is based on a single subject, the findings should be interpreted as preliminary. Future studies with a larger sample size are necessary to confirm whether these results are representative of the broader population of music teachers/conductors.

While people may habituate to noise exposure to some degree, the level of habituation varies among individuals, and negative health outcomes can still arise, especially with chronic exposure. Previous studies have shown that chronic exposure to excessive noise levels can lead to a range of auditory and non-auditory health issues, including hearing impairment, hypertension, heart disease, and sleep disturbance[9].

Another interesting point is that the acoustical conditions for that musical hall could mostly reflect the high-frequency sounds generated by the music bands. This is mainly related to the reverberation of the hall walls. In fact, a previous study showed that participants of musical conductors from different hall settings identified reverberation, balance, and musician connection as the key features of concert halls. Their favorite venues, all traditional "shoebox" designs, reflected these attributes. Many conductors reported compromising their musical interpretations due to acoustic issues, with balance and dynamics being the primary concerns[10].

This might also result in bouncing more sound energy into the hall area than expected. In other words, it could amplify the levels of noise generated from music-playing activities. This had also been approved by another study that examined the impact of hall/stage size and acoustics on noise exposure and instrument balance in seven concert halls, indicating that the acoustics of the hall can greatly increase noise exposure[11][12].

To solve this problem, some noise absorption materials should be applied to the rear wall, such as multi-resonators (which absorb noise at all frequencies) or at least some porous absorbers (which absorb noise at mid and high frequencies). Moreover, as a last resort, the exposed subject had better use hearing protectors that might reduce the noise levels by about 10 dBA.

6. Limitations

- These case study findings may not relate broadly, as they present a single subject exposure to noise.
- This was a single exposure measurement for 1 subject per day (for 2 separate days); that couldn't involve any further statistical analysis other than what was provided for a case study.

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Declarations

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