

Musicians' Daily Sound Exposure Assessed by Full-Day Dosimetry

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Abstract

In day-to-day life student musicians are often exposed to high-level sounds, that may be damaging for their hearing. At music universities, there are various obligatory activities, such as playing in the symphony or wind orchestra, playing in chamber ensembles or a Big Band. Many hours of individual practice is also mandatory. In every one of these activities, sound pressure levels are often high and the daily sound exposure levels often exceed the permissible limit of 85 dB. In this study, the exemplary results of the daily sound exposure are shown for a group of music students. In contrast to other studies, the measurements were carried out throughout the entire duration of the typical workday, so the calculated daily sound exposure level ($L_{EX,8h}$) is based on factual data, not estimations. Data concerning the A-weighted equivalent continuous sound pressure level in the function of time are presented for musicians playing the flute, clarinet, double-bass, percussion, trombone, trumpet and French horn, for every activity (e.g. lesson, rehearsal, concert). The daily sound exposure level values ($L_{EX,8h}$) are determined for each instrument.

Keywords: sound exposure, musicians, noise dosimetry, full-day dosimetry

1. Introduction

In their everyday work, musicians devote a lot of time to practicing the instrument - both solo and in chamber ensembles or orchestras. The sound pressure levels during these practice, as well as during performances, are often high and can lead to hearing loss. Over the past decades, musicians' exposure to sound has been the subject of many studies and measurements.

Studies available in the literature indicate that sounds occurring during playing in an orchestra and often exceed 90 dB [1-6]. Musicians playing wind instruments, especially brass, are exposed to the highest sound pressure levels [1, 7-9].

The research conducted so far has initially focused on sound exposure during performances with orchestras only. Exposure to sound during solo exercises was considered for the first time by Royster [7]. Measurement during individual exercises were carried out also by Laitinen [1] and Schmidt [3]. However, there is little work considering overall sound exposure during all activities involving musicians during a typical working day. Previously mentioned work involves measuring the sound pressure levels during a single event during the day, such as a rehearsal or concert. Exposure to sound (daily, weekly or annual) is either not determined, or based only on single event data, and does not take into account the fact that musicians are daily involved in a wide variety of music activities, rehearsals and hours of solo practice. Smith, Nielsen and Grimshaw conducted a study that takes into account all of the musicians' activities during the day [10]. They performed a two-day continuous

dosimeter measurement for a group of musicians, to indicate that the musicians were exposed to doses of sound exceeding the current standards.

The aim of this study was to estimate the daily noise exposure level ($L_{EX,8h}$), according to ISO 9612 standard [11] for a group of Fryderyk Chopin University of Music students, based on the measurement of the whole day of their musical activity, and to analyze how $L_{EX,8h}$ values depend on the type of activity and the type of instrument.

Due to the musical nature of the sounds being the subject of the research, in the following part of this study author uses the term “sound exposure” instead “noise exposure” which occurs in the ISO 9612 standard.

2. Measurement method

The research was conducted for a group of students from the Fryderyk Chopin University of Music in Warsaw playing flute, clarinet, double bass, drums, trombone, trumpet and horn. The musicians were asked to indicate the most typical day in their opinion, in terms of the type of classes and the number of hours spent at the university. On the day indicated by the musicians, after their arrival at the university, they were equipped with a portable dosimeter, microphones were mounted on their arms, and they received instructions on how to use the device properly. The survey participants were asked to fill in a table during the measurement, in which they specified the type of instrument, the type of activity (solo exercise, playing in a chamber ensemble, an orchestra) and the time of starting and ending of a given activity. The research was conducted for 7 musicians playing the flute, clarinet, trumpet, French horn, trombone, percussion and double bass. Due to the small size of the studied group, the results are exemplary.

The measurements were carried out using two two-channel personal noise dosimeters (Svantek SV 102+), equipped with SV 25D microphones. The dosimeters were calibrated using the BK 4231 calibrator. The microphones were placed on both sides of the head, on the musicians' shoulders, at a distance of about 10 cm from the ears. The devices recorded values of A-weighted equivalent continuous sound pressure level $L_{Aeq,T}$ [11] for every one second of measurement time ($L_{Aeq,1s}$). The resulting material was checked for artifacts such as accidental hitting of the microphone and samples with artifacts were not considered for further analysis. Based on the obtained $L_{Aeq,1s}$ values and the duration of all activities, daily sound exposure level, i.e. A-weighted noise exposure level normalized to an 8-hour working day ($L_{EX,8h}$) [11], was determined for each instrument.

3. Results

The recorded $L_{Aeq,1s}$ waveforms as a function of time for individual instruments are shown in Fig. 1a-g. The musical activities indicated by the musicians in the questionnaires were divided into 5 categories: solo practice - marked in green on the figures, playing in chamber ensembles - yellow, symphony orchestra - red, wind orchestra - blue and Big Band - violet. The range of time spent on each of the above mentioned activities is marked in Fig. 1a-g with rectangles in aforementioned colours.

The graphs show the $L_{Aeq,1s}$ values separately for the right (red) and left ear (blue), but the level difference between the right and left ear is not analyzed in this work (see [12]).

In the case of the flutists (Fig. 1a), it can be seen that the highest $L_{Aeq,1s}$ values occur during individual practice, sometimes exceeding even 120 dB. Most of the day is spent playing in chamber ensembles, where $L_{Aeq,1s}$ often exceeds 100 dB. For a musician playing the clarinet (Fig. 1b) during solo exercises, $L_{Aeq,1s}$ values are lower than when playing in a wind orchestra (blue rectangle) or in a chamber ensemble. The biggest exposure to sound during the measured day was the rehearsal of a chamber ensemble lasting more than 2 hours, during which the $L_{Aeq,1s}$ values ranged from 80-100 dB. In the case of the trumpet (Fig. 1c), as in the case of the flute, the highest $L_{Aeq,1s}$ values occur during the solo practice. In the case of the trumpet, the $L_{Aeq,1s}$ values during this activity are in the range of 100-110 dB. During rehearsals of a symphony orchestra (red rectangle), $L_{Aeq,1s}$ sometimes also exceed 100 dB, but there are also many times when the values of $L_{Aeq,1s}$ are low - these are moments when the musicians do not play because they listen to the conductor's speaking. For a trombone player (Fig. 1d), the highest $L_{Aeq,1s}$ values occur during an hour and a half long Big Band rehearsal (violet rectangle), exceeding 110 dB. One can also pay attention to the blue rectangle - a rehearsal of a wind orchestra, during which in the first and second half of the time a different repertoire is practiced and the course of $L_{Aeq,1s}$ has a different character for these parts.

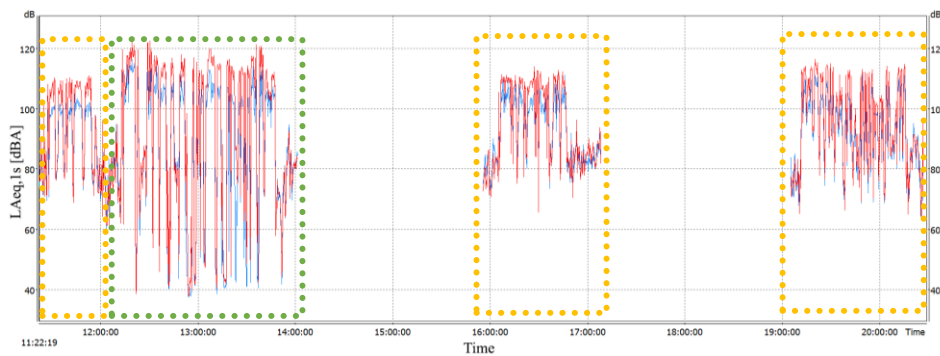


Figure 1a. Flute

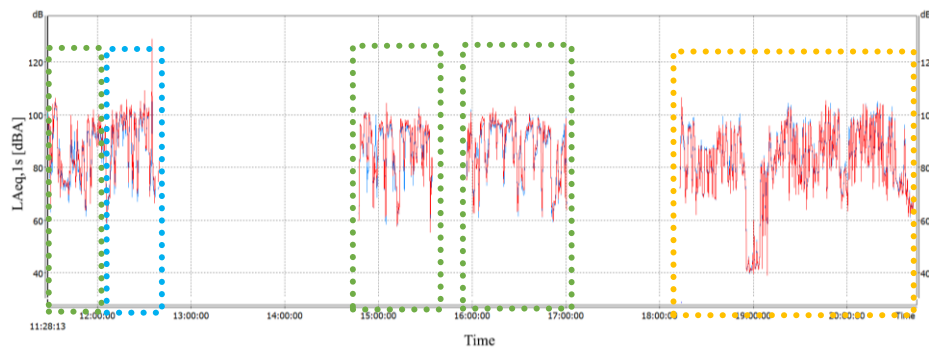


Figure 1b. Clarinet

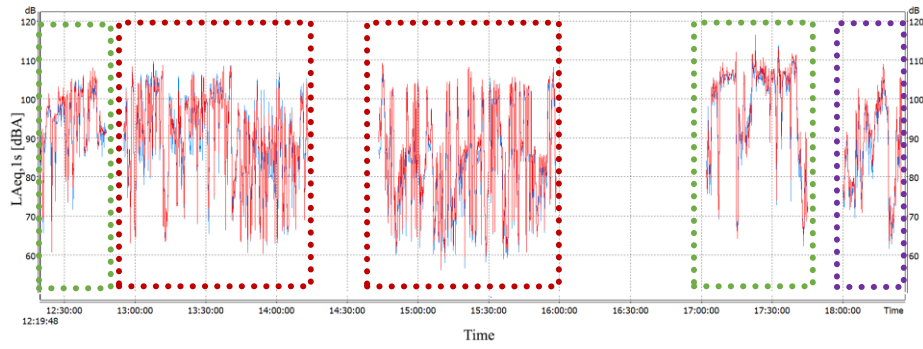


Figure 1c. Trumpet

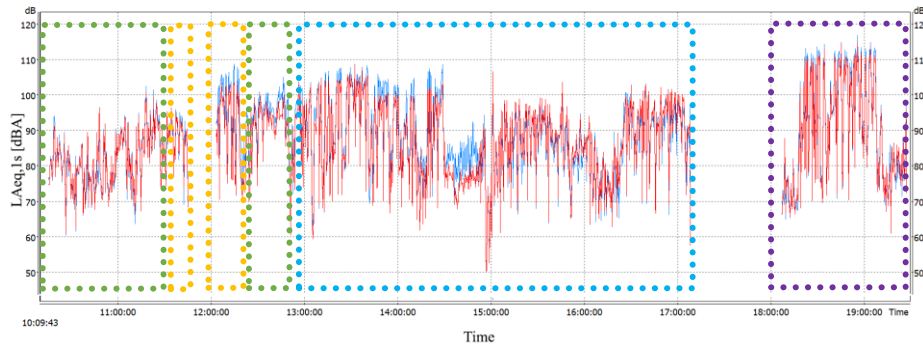


Figure 1d. Trombone

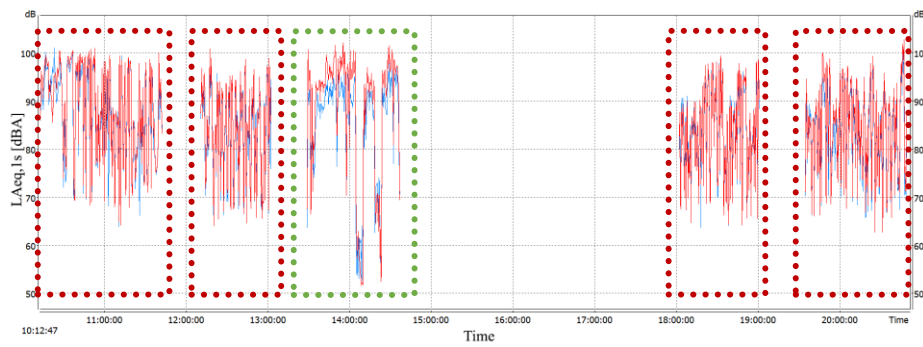


Figure 1e. French horn

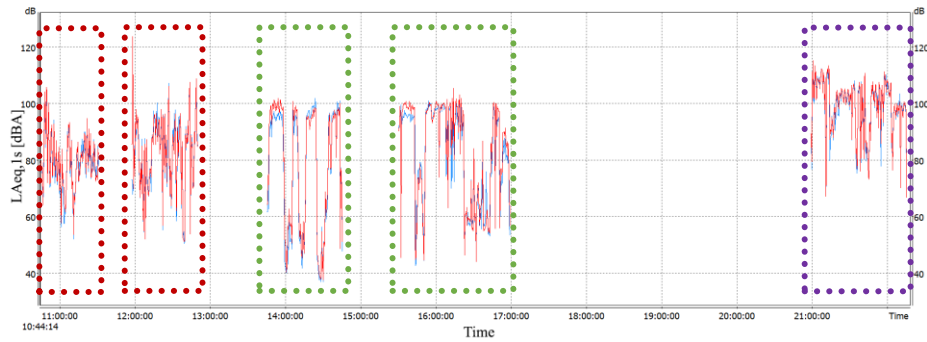


Figure 1f. Percussion

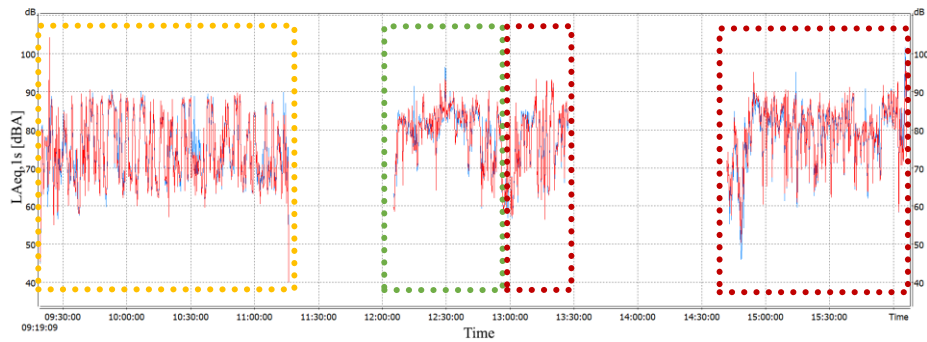


Figure 1g. Double-bass

Figure 1a-g. A-weighted equivalent continuous sound pressure level $L_{Aeq,1s}$ in the function of time (left ear – blue line, right ear – red line). Different types of activities are marked with rectangles in different colours: individual practice – green, chamber ensembles – yellow, symphony orchestra – red, wind orchestra – blue, Big Band – violet

On the figure concerning the French horn (Fig. 1e), it can be noticed that the course of $L_{Aeq,1s}$ during solo practice is of a different character than during rehearsals of a symphony orchestra. When playing solo, high sound pressure level is maintained for longer periods of time compared to a symphony orchestra. For both of these activities, $L_{Aeq,1s}$ values often exceed 90 dB. For the musician playing the percussion (Fig. 1f), the largest exposure took place during a Big Bang rehearsal, where the level often exceeded 100 dB. As in the case of French horn, during solo practice of percussionist, $L_{Aeq,1s}$ has high values for longer periods of time, than during orchestra rehearsals. The graph concerning the double-bass player (Fig. 1g) shows that $L_{Aeq,1s}$ values to which a bassist is exposed are lower than those of other instruments and only occasionally exceed 90 dB. The lowest values of $L_{Aeq,1s}$ for double bass occur during a chamber ensemble rehearsal, and the highest during symphony orchestra rehearsal.

Based on the recorded values of $L_{Aeq,1s}$ and on duration of sound exposure for each instrument, a daily sound exposure level, $L_{EX,8h}$, was determined in accordance with ISO 9612 standard [11]:

$$L_{EX,8h} = L_{Aeq,T} + 10 \lg(T_e / T_0) \quad [\text{dB}] \quad (1)$$

where T_e is the effective duration, in hours, of the working day, $L_{Aeq,T}$ [dB] is the A-weighted equivalent continuous sound pressure level for T_e , and T_0 is reference duration of 8 hours.

Obtained data are presented in Tab. 1. Effective duration T_e for each instrument is the total time of recording, i.e. the sum of time of every measured event (not the continuous time from start to end of the day). The A-weighted equivalent continuous sound pressure level L_{Aeq,T_e} is calculated over the entire measurement duration T_e . In Tab. 1 there is also information about activities that took place during the day in question for each instrument. “Individual” – meaning solo practice, “chamber” – playing in chamber ensembles, “SO” – playing in Symphony Orchestra, “WO” – Wind Orchestra, “Big Band” – playing in Big Band ensemble. The determined daily sound exposure levels ($L_{EX,8h}$) are given in the last column.

Table 1. Type of music activities during the day of measurement, A-weighted equivalent continuous sound pressure level $L_{eq,Te}$, effective duration T_e , and daily sound exposure level $L_{EX,8h}$ determined for each instrument

Instrument	Activities	$L_{eq,Te}$ [dB]	T_e [h, min]	$L_{EX,8h}$ [dB]
Flute	individual, chamber	102.9	5 h 13 min	101.0
Clarinet	individual, chamber, WO	91.4	5 h 29 min	89.8
Trumpet	individual, SO, Big Band	96.1	4 h 2 min	93.1
Trombone	individual, WO, Big Band	93.9	7 h 54 min	93.8
French horn	individual, SO	86.8	5 h 43 min	85.3
Percussion	individual, SO, Big Band	94.1	5 h 23 min	92.4
Double-bass	individual, chamber, SO	78.7	4 h 43 min	76.4

Conducted measurements show that on a typical university day, students playing flute, clarinet, trumpet, trombone, horn, and percussion are exposed to sounds that exceed the permissible limit of 85 dB during the day. Although musicians usually spend about 5 hours at university, the sound pressure level during this time is so high that the $L_{EX,8h}$ is exceeded. Musicians playing the flute are exposed to the highest A-weighted sound pressure levels, which during their playing often significantly exceeds 100 dB and the level of $L_{EX,8h}$ is 101 dB. Assuming a 3-dB exchange rate in accordance with the safety guidelines, the safe working time at this level is less than 15 minutes. For musicians playing the trumpet, trombone and percussion, $L_{EX,8h}$ exceeds 90 dB. The results are consistent with the literature, which indicates that the greatest exposure to sounds is for the wind instruments players. For musicians playing the clarinet and French horn, $L_{EX,8h}$ is also above the 85 dB limit. The only instrument for which the daily sound

exposure level does not exceed the permissible limit is the double bass. Although the exposure time is comparable to other instruments, the A-weighted sound pressure level generated by the double bass is low and there is no risk of over-exposure to sound.

4. Conclusions

Students of the Fryderyk Chopin University of Music playing the flute, clarinet, trumpet, trombone, French horn, and percussion in the course of daily activities are exposed to sounds of a level exceeding the 85 dB limit specified in the standards. Such high levels of sound can affect musicians' hearing and can lead to temporary and permanent noise induced hearing loss. The greatest exposure to sound occurs when playing the flute, in which case the daily sound exposure level ($L_{EX,8h}$) is 101 dB. The permissible limit is also exceeded for wind instruments: clarinet 89.8 dB, trumpet 93.1 dB, trombone 93.8 dB, French horn 85.3 dB, and percussion 92.4 dB. Among the studied instruments, only musicians playing on double-bass are not at the risk of excessive exposure to sound. This results indicate that daily sound exposure levels are highest for musicians playing wind instruments, which is consistent with the results of the studies cited in the introduction. The value of the daily sound exposure level depends on the type of instrument as well as the type of musical activity. Some instrumentalists are exposed to the highest A-weighted sound pressure level during solo practicing (flute, trumpet, horn), others (clarinet, trombone, drums, double bass) have the highest levels when playing in chamber ensembles and orchestras (symphony orchestra and Big Band). For the musicians playing the clarinet, the highest levels are in chamber ensembles, for trombonists and percussionists when playing in the Big Band, and in the case of double bass – when playing in a symphony orchestra. The presented analyses are based on a measurement carried out for a small group of people, so their character is rather exemplary. However, it can be seen that full-day noise dosimetry provides information about musicians' actual exposure to sounds during a variety of daily activities, unlike studies that consider only one type of noise. It is planned to continue the study for a larger group of musicians.

Acknowledgments

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