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Research Article

Noise Exposure of Physical Education Teachers – Empirical Study Using Measurement of Sound Pressure Level (SPL)

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Abstract

Background: Noise exposure has been determined as important stress factor in many occupations. Physical Education (PE) teachers also commonly report high noise exposure during class time. **Objective:** The present study provides objective data on noise exposure in various PE settings. **Material and Methods:** Weighted sound pressure levels (SPLs) were measured via a sound analyzer during PE lessons in single, double and triple gymnasiums as well as an indoor pool and dance room in middle schools. In addition, weighted SPLs were measured in a regular classroom during a Geography lesson. **Results:** Average weighted SPLs were above >80 dB(A) in every PE setting and peak values were above 100 dB(A). Average and peak SPLs were up to 20 dB(A) higher than measurements in a regular classroom. **Conclusion:** As weighted SPLs above 80 dB(A) have been associated with increased risk for hearing loss and cardiovascular disease, efforts to reduce noise exposure during PE including structural and organizational measures should be implemented.

Keywords: Noise; School sports; Gymnasium; Indoor pool; Occupational stress

Introduction

Several studies have adressed various contributors to stress in physical education (PE) teachers in the last several years [1,2]. In addition to disciplinary problems, lack of motivation, poorly equipped gymnasiums and large class sizes, high noise levels have been suggested as key stressors in PE teachers [2-5]. High noise levels have been associated with disturbance of concentration, increased fatigue, reduced performance, headaches and increased risk for cardiovascular diseases [4,6,7]. As such noise exposure is a key aspect in teaching and learning processes.

In regular classrooms, noise levels between 50 and 70 dB(A) have been reported previously [7,8]. In gymnasiums and indoor pools, these levels are most likely exceeded due to physical activities, particularly during ball games, as well as unfavorable acoustic conditions such as reverberation. Long reverberation time has been shown to be a key problem. Further, larger gymnasiums are often divided into 2 or 3 separate spaces with PE classes held side-by-side. Divider screens, however, serve primarily as visual protection but are not useful as acoustic barrier. Accordingly, average noise levels above 80 dB(A) have been reported with peak noise levels exceeding 100 dB(A) [3,9]. Noise exposure of 100 dB(A) is comparable to the noise of a circular saw in close proximity or that of a jet in 200 m distance [6].

In addition, it has been shown that 1 in 5 PE teachers reaches a cross-talk level of at least 75 dB(A) [10], which can be explained by the Lombard effect. The Lombard effect describes the phenomenon that people talk louder in noisy conditions, which further increases the overall noise level [5,11-13]. Besides the increased risk for hearing problems this increases the risk for voice problems in teachers, particularly in PE teachers [1,14,15]. Further, PE teachers have been complaining more commonly about increased noise sensibility at home, which negatively affects their leisure time [16]. Additionally, noise can increase the risk for mistakes of teachers and pupils as it impairs communication and concentration [11]. Accordingly, Wegener et al. [17] reported that high noise exposure decreases performance and leads to negative emotions. Social behaviors such as impatience, anger and agression, therefore, may become more prominent, which may increase overall stress of PE teachers [17].

Given the profound effects of noise exposure on general health and wellbeing, the present study examines noise levels in gymnasiums and indoor pools via objective measures in order to quantify the commonly reported high noise exposure of PE teachers.

Material and Methods

Sound pressure measurements were taken at 4 Tyrolean (Austria) middle schools in various gymnasiums (single gym, double gym, triple gym, and dance room), an indoor pool and a regular classroom. Noise was measured in 6 classes, with specifics of measurement time, number of students and grade summarized in Table 1. Measurements were taken throughout the entire class-time. The measurement device was positioned at a height of 160 cm and moved around in order to maintain close proximity to the teacher. Movements of the device as well as class structure were recorded. Between 15 and 20 students 11- to 14-years of age were present during the measurements in gymnasiums, an indoor pool and a regular classroom. The indoor pool was only available to students at the time of measurement in order to avoid contamination due to public use. Double and triple gyms were separated by screens. The measurement in the classroom was performed during a Geography lesson.

Room	Measurement Duration*	Class Time*	Number of Students in class	Grade
Indoor pool	62 min	100 min	20	6
Triple-Gym	35 min	100 min	19	6
Single Gym	82 min	100 min	21	8
Dance room	30 min	50 min	15	6
Double-Gym	86 min	100 min	20	8
Classroom	48 min	50 min	21	7
*single class sessions last 50 minutes but PE commonly uses 2 class sessions (i.e. 100 min) Differences in measurement times are due to time lost for changing clothes and transfer to specific settings.				

Table 1: Duration of measurements in various settings.

Quantification of noise exposure: To quantify the level of exposure to sound and particularly to unpleasant sound (which is colloquially described as “noise”) by technical means, the respective quantities and units naturally must be adapted to the modes of human sound perception. Physically, sound volume is quantified by the sound pressure level (SPL), which is proportional to the logarithm of the ratio of the actual sound pressure and a standard sound pressure expressed in decibel (dB). The standard sound pressure is 20 μPa corresponding to the normal hearing threshold at frequencies of 1000 Hz [18]. To account for the dependence of the sensitivity of the human ear on sound frequency, frequency spectra in sounds are analysed and weighted using low weights for low and high weights for mid and high frequencies ranging between approximately 500 and 10000 Hz. Weighted SPL is expressed in dB(A), where A stands for the A-filter according to the IEC 61672 standard [19].

Measurements: A standard sound level meter for assessment of occupational noise exposure (Type 2250 Brüel & Kjær, Nærum, Denmark) with a measurement range of 120 dB was used. During each session, A-weighted SPLs were continuously recorded with a sampling rate of 100 Hz. Weighted SPLs were then averaged over time and sound exposure levels (SEL) were calculated as a measure of total sound exposure. Simultaneously, the activities during the lesson were recorded to provide information on causes of sound peaks.

Data Analysis: Data analysis was performed with the software of the measurement device (Utility BZ5503), which provides average as well as peak SPL. Data was subsequently exported into MS Excel and Matlab for descriptive evaluation and the preparation of figures.

Results

Average weighted SPLs were approximately 20 dB(A) higher during PE classes than during regular class time (Figure 1).

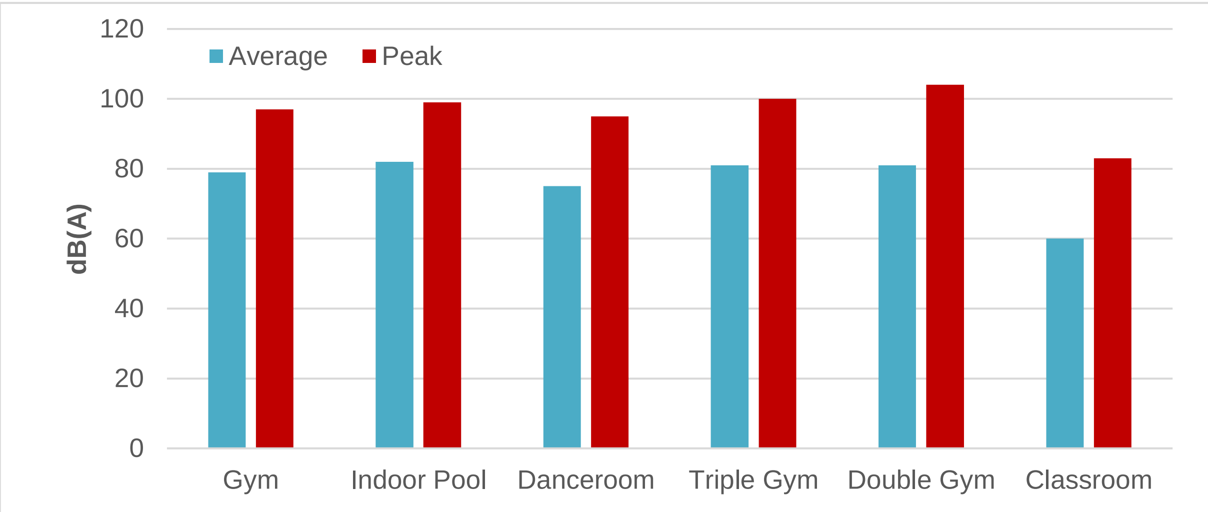

Figure 1: Average and peak weighted SPL in different settings.

All measurements during PE reached at least 75 dB(A), with highest average weighted SPLs occurring in the indoor pool, double and triple gyms (> 80 dB(A)). In double and triple gyms peak weighted SPLs exceeded 100 dB(A). In the indoor pool and dance room peak weighted SPLs were close to 100 dB(A), while peak weighted SPL in the classroom was approximately 80 dB(A).

Results of the continuous weighted SPL measurements at various settings are shown in figures 2-7. As a level of 80 dB(A) has been associated with detrimental health effects, this threshold is highlighted.

Indoor Pool: Weighted SPLs were continuously high in the indoor pool (Figure 2). Particularly in the later stages of the lesson weighted SPLs increased and reached continuously levels above 80 dB(A) with peak weighted SPL at the end reaching almost 100 dB(A).

Triple Gym: During PE classes in a triple gym weighted SPLs were almost constantly above 80 dB(A), particularly during the first part of the lesson. Peak values at the beginning and end of the lesson reached above 100 dB(A) (Figure 3).

Double Gym: Weighted SPLs in the double gym were continuously around 80 dB(A) with peak values between 90 und 100 dB(A). Early in the lesson a peak SPL above 100 dB(A) occurred (Figure 4).

Gym (Single): Throughout the entire class period weighted SPLs remained around 80 dB(A). During the second half peak values above 90 dB(A) were more frequent (Figure 5).

Dance room: Weighted SPLs throughout the entire class period remained between 60 and 80 dB(A) with peak values above 95 dB(A) (Figure 6).

Classroom (Geography): During a Geography class in a regular classroom setting weighted SPLs remained between 45 und 70 dB(A) (Figure 7) with a peak level above 80 dB(A) only occurring at the beginning of the class period.

Discussion

The present study determines noise exposure via objective SPL measurements in various PE settings and a regular classroom. Results showed that PE teachers are exposed to higher noise levels than those experienced in regular classrooms, with particularly high volumes reached in indoor pools and in triple gyms. Classroom measures indicated an average noise exposure of 60 dB(A), while average values during PE were around 80 dB(A), which is comparable to noise levels in the range of loud street traffic.

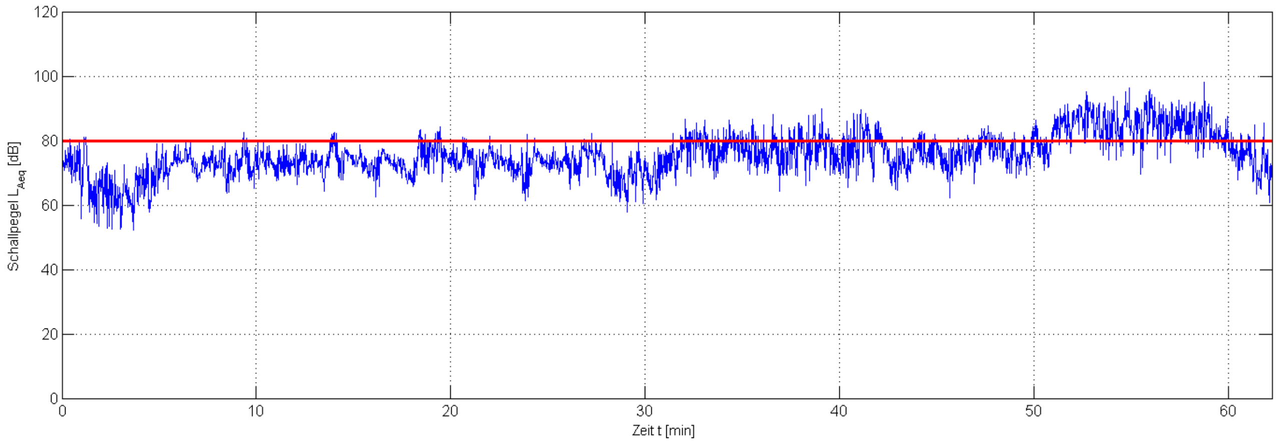

Figure 2: Weighted SPL during PE in an indoor pool.

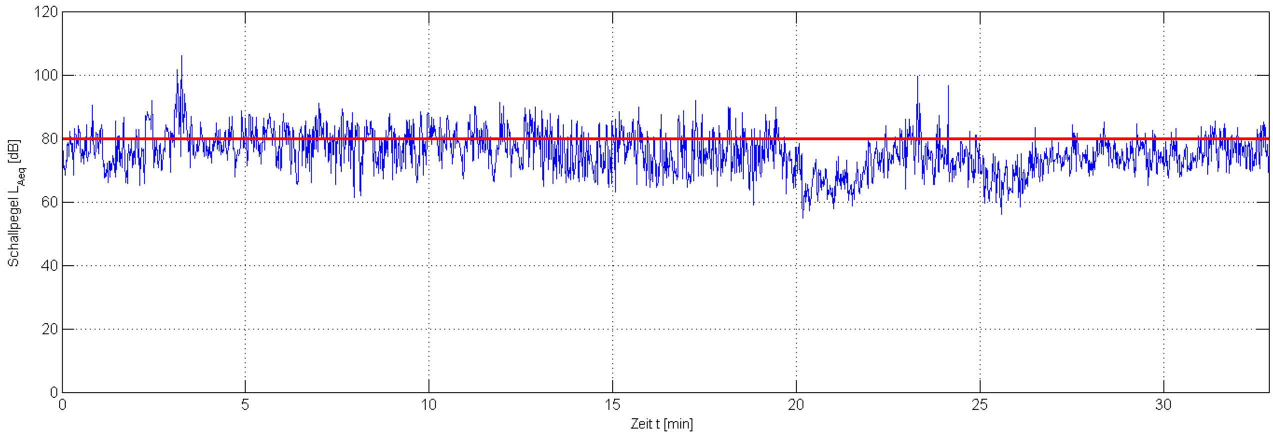

Figure 3: Weighted SPL during PE in a triple gym.

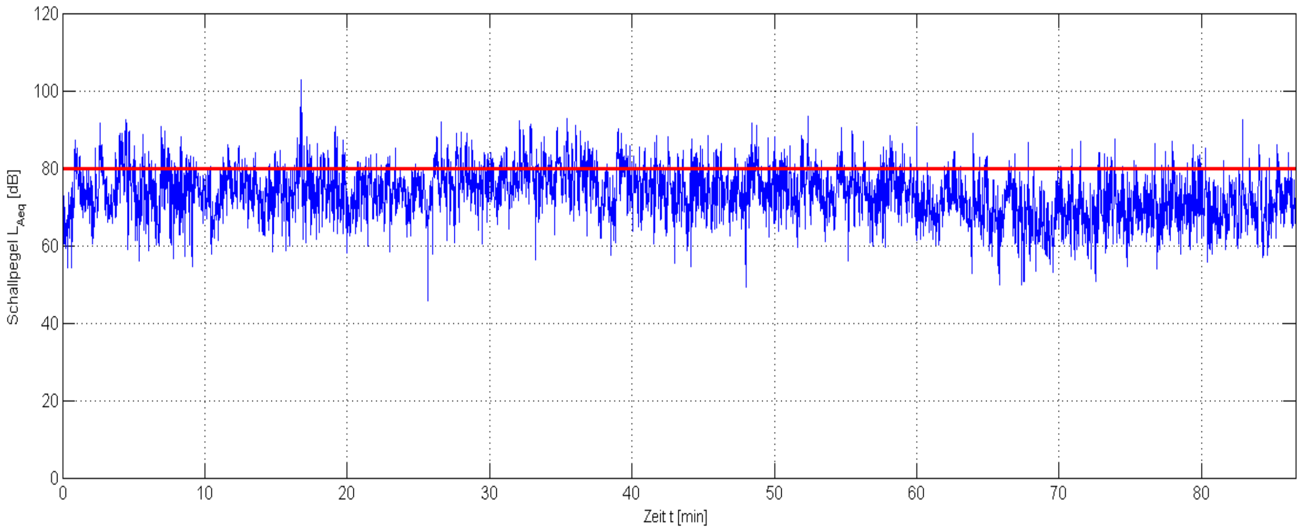

Figure 4: Weighted SPL during PE in a double gym.

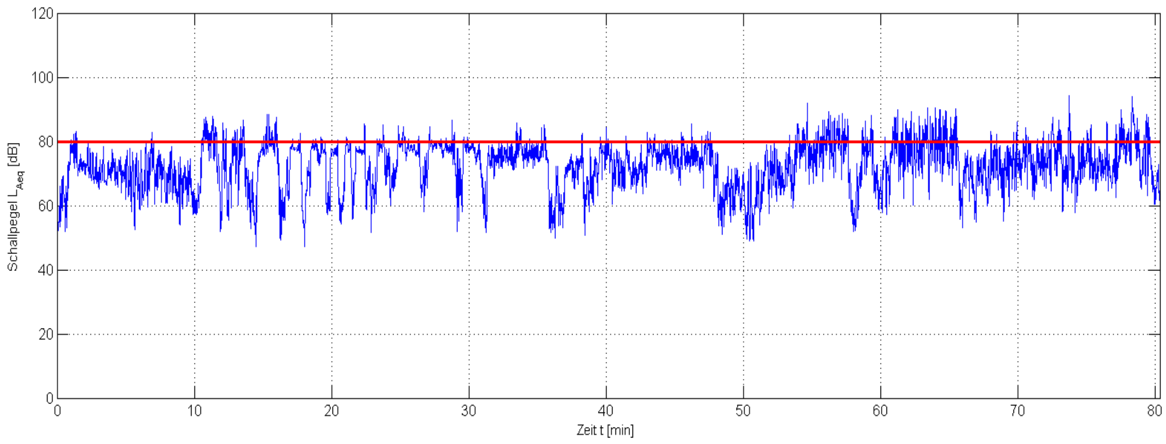

Figure 5: Weighted SPL during PE in a single gym.

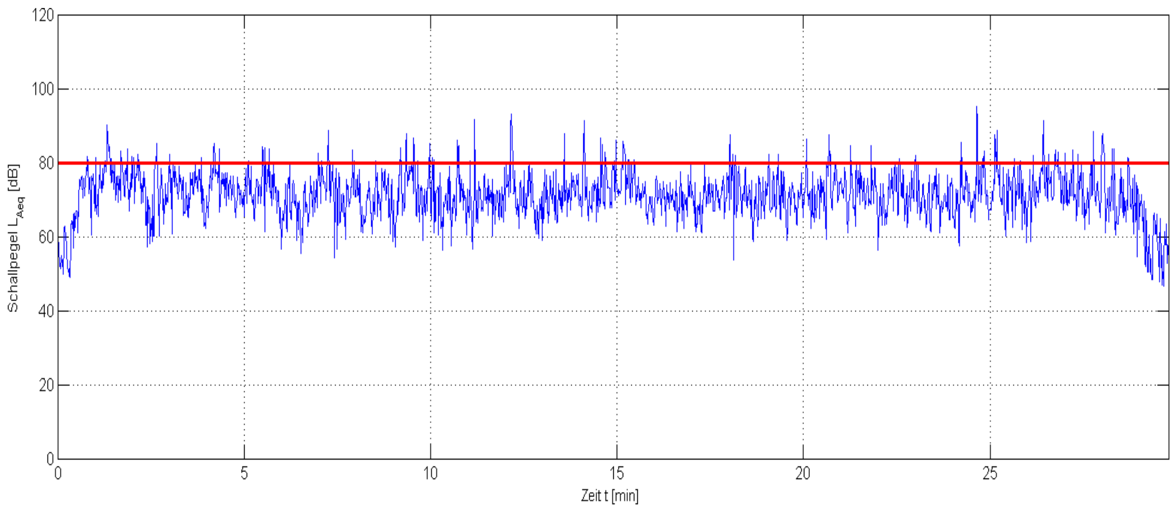

Figure 6: Weighted SPL during PE in a dance room.

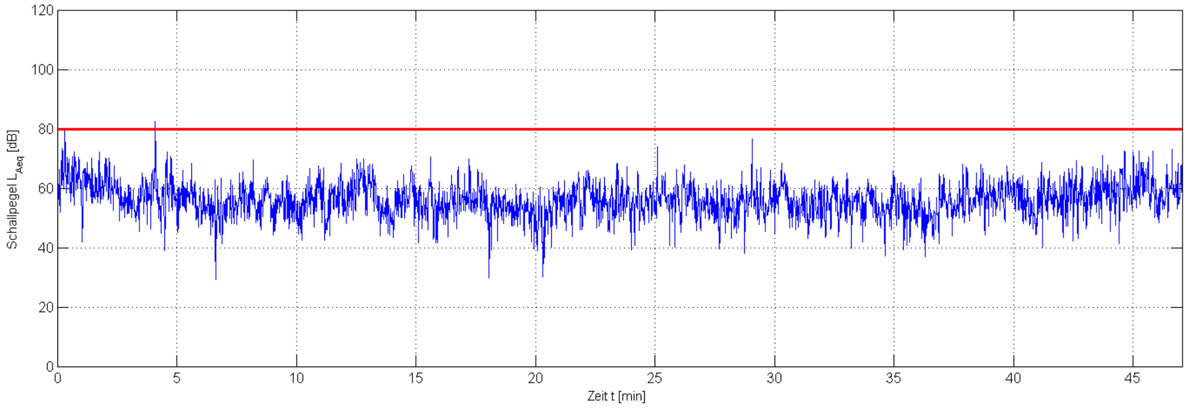

Figure 7: Weighted SPL in a classroom during a geography lesson.

Similar results have been shown in previous studies [4,7], which also supports subjective reports of increased noise exposure during PE classes [1]. Differences in peak weighted SPLs between classroom and PE settings also reached 15 to 20 dB(A). These differences are considerable as increases in sound pressure levels are scaled logarithmically rather than linearly. As such an increase in noise exposure of 10 dB(A) doubles the subjective sensation of noise.

High noise exposure has been associated with several health consequences including aural, vocal, psychological and cardiovascular problems. In addition to an increased risk of hearing problems and hearing loss [6], increased noise necessitates a louder speaking voice while teaching. This increases the risk for hoarseness and vocal problems [5,14,15,20]. Additionally, noise exposure has been associated with increased fatigue and headaches [4,7]. High occupational noise has also been shown to increase depressive symptoms, which may become as severe as suicidal thoughts [21]. Further, there is evidence that sustained exposure to noise levels above 65 to 70 dB(A) increases the risk for cardiovascular disease [22,23].

Besides detrimental effects on the teacher, high noise levels may also impair the learning process in students. It may limit students' ability to understand instructions and feedback [17]. In addition, high noise exposure has been shown to impair motivation, increase aggressive behavior and fatigue, which negatively affects the learning environment [7]. These factors also contribute to disciplinary problems in the classroom. In fact, Wegener et al. [17] argue that unfavorable acoustic conditions are a key contributor to disciplinary problems in the classroom. Accordingly, noise reduction is a critical aspect not only for teachers' and students' health but also for enhancing learning experiences and pedagogical outcomes.

Given that PE involves various forms of physical activity it can be expected that noise levels will increase during such lessons. Active movement during PE is necessary to compensate for the prolonged sitting times during the school day and has been shown to reduce aggression [24]. As such noise is part of physical activity and PE. Nevertheless, high noise exposure along with unfavorable acoustic conditions has been associated with problems in motivation and performance as well as increased risk for various health outcomes [4,7,17,21,25].

Structural adaptations, such as sound absorbing wall and ceiling panels, for example, could help in minimizing noise exposure. Particularly wall coverings using textile materials have been associated with improved acoustic conditions. The utilization of ear protection (e.g. ear plugs) has been discussed as well. Even though some teachers may use this strategy to filter uncomfortable peak values, Wegener et al. [17] caution against the use of ear plugs due to the increased risk of disengagement from the classroom situation. Rather behavioral and organizational adjustments may be helpful. Distance and direction when communicating with students, for example, has been shown to significantly affect noise [17].

Conclusions

Given the limited objective data of noise exposure in different educational settings this article provides valuable information for preventive measures and policy decisions. The results clearly show an increased noise exposure of PE teachers compared to teachers of other subjects. PE teachers experience a continuous exposure to noise at or above 80 dB(A), which has been associated with detrimental health effects, including aural, vocal, psychological and cardiovascular problems. As such occupational medical reports should consider noise levels in PE settings and provide information on the potential health risks to PE teachers. Further, efforts, including structural adaptations, class-size and teaching style, to minimize noise exposure while still allowing children and youth to engage in high levels of physical activity are warranted.

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