

IMPACT OF EXPOSURE TO OCCUPATIONAL NOISE ON HEARING AND BLOOD PRESSURE: A REVIEW

Impacto da exposição ao ruído ocupacional na audição e na pressão sanguínea: revisão

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Abstract

The purpose of this review is to identify the effects of occupational noise exposure on hearing and blood pressure and to determine its implications for dental personnel.

Although results differ among the studies reviewed, researches have demonstrated that exposure to high levels of noise can unchain similar cardiovascular answers to that they occur in acute stress, releasing stress hormones (corticotropin hormone; adrenocorticotropic hormone) and causing a significant increase in blood pressure. The dental office is a noise polluted environment which can cause hearing loss. None study evaluated the relationship between noise-induced hearing loss and blood pressure levels among dental personnel. The majority and the most recent papers indicate high levels of noise (above of 80 dB(A), and with frequencies ranging from 2,000 to 4,000 Hz) appear to affect heart rate and blood pressure. The high-speed dental air turbines emit frequencies which can cause hearing loss.

Keywords: Hypertension; Noise; Occupational health; Blood pressure; Hearing loss; Dental personnel.

Resumo

O presente estudo revisou a associação entre a exposição ao ruído no ambiente de trabalho e a hipertensão arterial entre profissionais de Odontologia. Embora existam resultados controversos na literatura, a maioria das pesquisas demonstrou que exposições a altos níveis de ruído podem desencadear efeitos cardiovasculares similares aos que ocorrem no estresse, liberando hormônios (corticotropina e adrenocorticotropina) e causando aumento da pressão arterial. O ambiente do consultório odontológico é sonoramente poluído e pode causar perda auditiva. Estudos recentes indicam que altos níveis de ruídos (acima de 80 dB(A) na frequência entre 2.000 e 4.000 Hz) afetam a taxa cardíaca e a pressão arterial. As turbinas de ar utilizadas na Odontologia emitem frequências que podem causar perda auditiva, mas nenhum estudo avaliando a relação entre perda auditiva e pressão arterial entre profissionais da Odontologia foi realizado.

Palavras-chave: Hipertensão; Perda auditiva; Ruído; Saúde Ocupacional; Cirurgião-dentista; Pressão arterial.

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Introduction

Hearing Loss

Exposure to high levels of noise is a very common occupational health problem (1). Millions of workers worldwide are exposed to noise pressure levels capable of causing harm. Unfortunately, hearing loss is a significant and common occupational malady and is considered the second most frequently self reported occupational illness or injury (2).

Although hearing ability declines with age (presbycusis), exposure to noise affects hearing ability more severely than presbycusis. In most cases, noise-induced hearing loss is insidious. The intensity, the frequency variation and daily exposure time must be considered when evaluating the relationship between hypertension and noise exposure in workers. The A-weighted decibel [dB(A)] is the preferred unit for measuring sound levels in order to assess exposure to noise. The dB(A) represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the large range of sound pressure levels audible to the human ear. Because the dB(A) scale is logarithmic, noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean. A worker can be exposed to 85 dB(A) for 8 hours,

but to no more than 88 dB(A) for 4 hours or 91 dB(A) for 2 hours (3).

The OSHA (National Institute for Occupational Safety and Health – USA) (4) standard for occupational exposure to noise specifies a maximum permissible exposure limit (PEL) of 90 dB(A) for eight hours. When the sound level (L) is constant over the entire work shift the noise dose (D) in percent is calculated using: $D=100 C/T$, where C is the total length of the work day in hours and T is the reference duration corresponding to the measured sound level (L) as given in Table 1 (Table G-16a of the Occupational Safety and Health Administration (OSHA) - USA) or by the formula:

$$T = \frac{8}{2^{(L-90)/5}}$$

where L is the measured A-weighted sound level.

When the workshift noise exposure is composed of two or more periods of noise at different levels, the total noise dose over the work day can be calculated as follows:

$$D = 100 (C(1)/T(1) + C(2)/T(2) + \dots + C(n)/T(n))$$

Where C(n) indicates the total time of exposure at a specific noise level, and T(n) indicates the reference duration for that level as given by Table 1(4).

Table 1 – Abbreviated Table G-16a of the OSHA for computation of employee noise

A-weighted sound level, L (decibel)	Reference: duration, T (hour)
80	32
85	16
90	8
95	4
100	2
105	1
110	0.5
115	0.25

A person may be exposed to noise levels of 95 dB(A) for no more than four hours, to 100 dB(A) for two hours, etc. Conversely, up to sixteen hours of exposure to 85 dB(A) is allowed by this exchange rate. During any 24-hour

period, a worker is allowed up to 100 percent of his/her daily noise dose. Doses greater than 100 percent are in excess of the OSHA standard. The limits for noise in Brazil are shown in Table 2 (5).

Table 2 – Limits for continuous and intermittent noise

Noise dB(A)	Maximum daily exposure tolerate
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours and 30 minutes
90	4 hours
91	3 hours and 30 minutes
92	3 hours
93	2 hours and 40 minutes
94	2 hours and 15 minutes
95	2 hours
96	1 hours and 45 minutes
98	1 hours and 15 minutes
100	1 hour
102	45 minutes
104	35 minutes
105	30 minutes
106	25 minutes
108	20 minutes
110	15 minutes
112	10 minutes
114	8 minutes
115	7 minutes

The ear is affected by noise in two different ways depending on the type of exposure. High-level, short duration exposures exceeding 140 dB(A) can stretch the delicate inner ear tissues beyond their elastic limits, resulting in rupture. This type of damage (acoustic trauma) occurs rapidly and results in immediate, permanent hearing loss. Otherwise, chronic exposure

to noise between 90 and 140 dB(A) damages the cochlea metabolically rather than mechanically and causes damage related to exposure and duration levels. Noise-induced hearing loss, in contrast to acoustic trauma, develops slowly over several years and is caused by any exposure exceeding a daily average of 90 dB(A) on a regular basis (6).

Hypertension

Additional effects also have been studied. Since 1970, the relationship between noise-induced hearing loss and blood pressure levels has been investigated (7). Studies have demonstrated that exposure to high levels of noise can unchain similar cardiovascular answers similar to that occur in acute stress (8, 9), releasing stress hormones (corticotropin hormone; adrenocorticotrophic hormone) and causing a significant increase in arterial pressure (10).

Being hypertension (according to World Health Organization criteria, diastolic ≥ 90 mmHg; systolic ≥ 140 mmHg) a very common health problem (11) and noise-induced hearing loss a common occupational disease(1), the objective of this study is to review the effects of occupational noise exposure on blood pressure and subsequently to connect it with dental personnel.

Literature review

The first study about exposure to high levels of noise as a possible risk factor in cardiovascular disease were realized by Glass & Singer, in 1972 (12). It was concluded that high levels of noise are a stress factor. Some years later, other studies showed that there was no relationship between high levels of noise and hypertension (13-15). After these first studies, workers from different sectors, mainly from noisy factories and those exposed to noise ranging from 65 to 115 dB(A) were evaluated (16, 17). There was no relationship between hearing loss and hypertension was found. Hessel & Sluis-Cremer (18) reviewed the medical history and personnel records of 2,197 white male South African miners; Correa Filho et al (19) estimated the prevalence of occupational noise-induced hearing loss and arterial hypertension among city bus drivers. These studies showed no association between blood pressure and noise exposure.

However, Garcia & Garcia (20) found a relationship between arterial pressure and exposure to noise at work in workers who had hearing loss above 65 dB(A) for the frequency of 4,000 Hz (indicator of greater exposure to noise). Tomei et al (21) showed that the prevalence of hypertension and electrocardiographic modifications in basal conditions and under the stress test differed to

a significant extent in relation to different intensities of exposure to noise. Non-occupational risk factors studied (cholesterol, blood glucose, smoking, body mass index, family history of cardiovascular problems) showed no significant differences between the group exposed to noise and the control group.

More recent studies evaluated workers in a metallurgical factory (22), bedframe factory (23) and oil-drilling industry (24). The authors concluded that noise can be a cardiovascular risk factor. Occupational exposure to noise levels exceeding 80 dB(A) (22) may lead to a higher prevalence of hypertension and to increased blood pressure values. Rocha et al (25) evaluated blood pressure and heart rate behavior in individuals during the working day in two environments with different work stressors, among them occupational noise exposure. Change of blood pressure and heart rate responded to stressor factors during the working day, indicating that these factors should be considered as potential factors for hypertension.

Others studies evaluated automobile workers (26) and aircraft pilots (10). The results showed that occupational noise levels ranging 85 dB(A) (26) to 93 dB(A) (10) can affect blood pressure. These findings suggested that chronic exposure to noise is a risk factor for blood hypertension. Another review found that hypertension was more prevalent among individuals living close to airports, suggesting that the cause was the high environmental noise levels. (27). However, exposure to environmental air pollution exposure is also a possible confounder/effect modifier of the association between noise and cardiovascular risk (28).

Discussion

Damage to the dentist's hearing because of the air turbine and others machines have been the subject of many articles (29-31). Audiometric data showed that hearing loss at 3,000 Hz (30) to 4,000 Hz (31) is presumably indicative of occupational noise trauma. Setcos & Mahyuddin (32) concluded that the noise levels in dental clinics are considered to be below the limit of risk of hearing loss. However, technicians and other personnel who spend many hours in noisy dental laboratories may be at risk if they choose not to wear ear protection. The noise level increases during cut-

ting when compared with non-cutting procedures (33). Morarasu et al (34) suggested that the dental practice is a noise polluted environment, although most of the sounds are below damaging levels to the human ear (85 dB(A)). In contrast, the results of Altinoz et al (35) indicated that under any working conditions, high-speed dental air turbines emit frequencies (the average measurement was 6,860 Hz) that can cause hearing loss. High frequencies noise can affect hearing at (10,000, 12,000 and 14,000 Hz) as well as at conventional frequencies (250 – 8,000 Hz) (36).

No study evaluated the relationship between noise-induced hearing loss and blood pressure levels among dentists and dentistry personnel.

The maximum noise level allowed by French Law is 90 dB(A) for an 8 hour working journey-and 140 dB(A) for peaks. With the objective of protection of all workers, a recent European Directive will decrease the maximum permissible level to 87 dB(A) in 2006 (37). The association between occupational noise exposure and blood pressure has important public health implications. The harmful effects of hypertension are well known and noise is considered the most pervasive of all occupational exposures. Cardiovascular effects due to noise exposure have been studied to some extent, but no clear exposure-response relations are currently known (38), although a recent German study showed that chronic exposure to high levels of traffic noise increases the risk for cardiovascular diseases (39).

According to Andren et al (9), noise stimulation (95 dB(A)) for 20 min caused a significant increase in diastolic pressure (12%). Melamed et al (40) monitored behavior, tension, and ambulatory cardiovascular reactivity in workers exposed to noise stress of 123 normotensive males. The results indicated that when workers were exposed to high noise levels ≥ 80 dBA, blood pressure and heart rate were positively related. When the same workers were exposed to low noise levels, the results were not significant. These results suggest that noise constitutes a stressor factor. After controlling for several potential confounding factors, Tarter & Robins (41) found significant association of mean blood pressure and hypertension among black workers. They presented hearing loss at 4,000 Hz, working during a minimum of 5 years in high-noise environments. However, the same results

were not found among white workers. This and other results made the authors think that probably there are others associated factors, but they are not yet clear. For instance, exposure to high sound levels can cause other effects on health, such as sleep disturbance and increased aggressive behavior (42). A recent study concluded that short sleep duration could be a significant risk factor for hypertension (43).

Stress hormones are useful indicators to study mechanisms and interactions between noise and blood pressure (44). Noise can cause different stress hormones to be released (e.g. corticotropin releasing hormone: CRH; adrenocorticotrophic hormone: ACTH). Animal experiments showed noise-induced changes in the sensitivity of cellular cortisol receptors by increase in heat-shock proteins, and ultrastructural changes in the tissue of the heart and the adrenal gland. Increased cortisol levels have been found in humans when exposed to aircraft noise or road traffic noise during sleep (45). Noise can cause significant acute increase of cortisol, which develops into chronic increase if the noise exposure is consistently repeated. Parallel to cortisol, chronic noradrenaline increase was also observed. Non-habituated noise primarily increased the release of adrenalin from the suprarenal medulla, whereas habituated noise caused a chronic increase of noradrenaline from the sympathetic synapses under long term noise exposure at work (46).

Hypertension is a very common health problem. In most countries, up to 30% of adults suffer from high blood pressure (47). Factors associated with high blood pressure are family history of hypertension, overweight and obesity, lack of physical activity, too much salt in the diet, too much alcohol consumption, stress and smoking (48). Although the causal relationship between noise exposure and high blood pressure have not been conclusively established, the majority of and the most recent studies indicate that it does appear to affect heart rate, blood pressure and the electrocardiogram. To identify and prevent possible health related effects, workplace monitoring, audiometry, and blood pressure screenings are essential (2).

One must consider that there has been a significant increase in exposure to noise in the 20th and 21st centuries, which could be correlated with the increase in the incidence of hypertension. However, others factors (overweight and obe-

sity, smoking habit, high consumption of alcoholic beverage and lack of physical activity) have increased as well, and are also associated. Studies have improved over the years, and many potential confounding factors have been considered. Some expert groups have rated the evidence of an association as sufficient (49, 50). For chronic exposure to noise levels above 80 dB(A) and hearing loss frequencies in the 2,000 to 4,000 Hz range, reactions or adverse health effects can be expected.

Conclusion

Several studies showed no clear relationship between occupational exposure to noise and arterial pressure. However, the majority and the most recent studies indicate that noise does appear to affect heart rate, blood pressure and the electrocardiogram, principally for chronic exposure to levels above 80 dB(A) and hearing loss frequencies in the 2,000 to 4,000 Hz range.

There is an on-going challenge to pay attention to workers health, to identify the risk factors for hypertension, such as overweight and obesity, smoking habit, the high consumption of alcoholic beverages or lack of physical activity, and to control the potential occupational risks, such as exposure to high noise levels.

Although high-speed dental air turbines and other dental machines emit frequencies that can cause hearing loss, no study evaluated the relationship between noise-induced hearing loss and blood pressure levels among dentists and dental staff.

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