Analysis of sound pressure levels emitted by children's toys

Análise dos níveis de pressão sonora emitidos por brinquedos infantis

Análisis de los niveles de presión sonora emitidos por juguetes infantiles

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ABSTRACT

Objective: To verify the levels of sound pressure emitted by non-certified children's toys.

Methods: Cross-sectional study of sound toys available at popular retail stores of the so-called informal sector. Electronic, mechanical, and musical toys were analyzed. The measurement of each product was carried out by an acoustic engineer in an acoustically isolated booth, by a decibel meter. To obtain the sound parameters of intensity and frequency, the toys were set to produce sounds at a distance of 10 and 50cm from the researcher's ear. The intensity of sound pressure [dB(A)] and the frequency in hertz (Hz) were measured.

Results: 48 toys were evaluated. The mean sound pressure 10cm from the ear was 102±10 dB(A), and at 50cm, 94±8 dB(A), with $p<0.05$. The level of sound pressure emitted by the majority of toys was above 85dB(A). The frequency ranged from 413 to 6,635Hz, with 56.3% of toys emitting frequency higher than 2,000Hz.

Conclusions: The majority of toys assessed in this research emitted a high level of sound pressure.

Key-words: play and playthings; noise measurement; child.

RESUMO

Objetivo: Verificar os níveis de pressão sonora emitidos por brinquedos infantis sem certificação.

Métodos: Estudo transversal com brinquedos sonoros ofertados em lojas de comércio popular, chamado de setor informal. Foram considerados brinquedos eletrônicos, mecânicos e musicais. A mensuração de cada produto foi realizada por um engenheiro acústico, em cabine isolada acusticamente, por meio de um decibelímetro. Para obter os parâmetros sonoros de intensidade e frequência, os brinquedos foram acionados a uma distância de 10 e 50cm da orelha do pesquisador. A intensidade foi verificada em nível de pressão sonora em decibéis dB(A) e a frequência, em hertz (Hz).

Resultados: Foram avaliados 48 brinquedos. Nas medidas a 10cm da orelha, foi registrada uma faixa de pressão sonora de 102±10 dB(A) e, a 50cm, a média foi de 94±8 dB(A), com $p<0,05$. A maioria dos brinquedos apresentou nível de pressão sonora acima de 85dB(A). A frequência variou de 413 a 6.635Hz, sendo que 56,3% dos brinquedos emitiram som com frequência superior a 2.000Hz.

Conclusões: Constatou-se que a maioria dos brinquedos emitiu sons com elevado nível de pressão.

Palavras-chave: jogos e brinquedos; medição de ruído; criança.

RESUMEN

Objetivo: Verificar los niveles de presión sonora emitidos por juguetes infantiles sin acreditación.

Métodos: Estudio transversal con juguetes sonoros ofrecidos en tiendas de comercio popular, del dicho sector informal. Se consideraron juguetes electrónicos, mecánicos y

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musicales. La medición de cada producto la realizó un ingeniero acústico en una cabina aislada acústicamente mediante un decibelímetro. Para obtener los parámetros de intensidad y frecuencia, los juguetes fueron accionados a una distancia de 10 y 50cm de la oreja del investigador. La intensidad fue verificada en nivel de presión sonora en decibelios dB(A), y la frecuencia en hertz (Hz).

Resultados: Se evaluaron 48 juguetes. En las medidas a 10 cm de la oreja, se registró una franja de presión sonora de 102±10 db(A), y a 50cm de la oreja, el promedio fue de 94±8 dB(A) (p<0,05). La mayoría de los juguetes presentó nivel de presión sonora superior a 85 dB(A). La frecuencia varió de 413 a 6635Hz, siendo que el 56,3% de los juguetes emitieron sonido con frecuencia superior a 2000Hz.

Conclusión: Se constató que la mayoría de los juguetes emitió sonidos de elevado nivel de presión.

Palabras clave: juegos y juguetes; medición de ruido; niño.

Introduction

Games are allies of child development, guiding learning through play and awakening the child's interest in the world[1-3]. Therefore, playing is essential for the social, emotional, physical, and cognitive development of children[2]. Sound toys are part of this playing universe and, besides entertaining and assisting children in aspects of development, they stimulate the sensory pathways of hearing[3]. However, caution is needed when providing sound-emitting toys to children, once they can produce excessively intense noise, causing risks to hearing health[3-6].

The human ear has a sound tolerance depending on the intensity and duration of exposure[7], a limit that must be respected especially for children undergoing oral language acquisition[8], since hearing is the primary sense that provides the development of this ability[9]. For the auditory system under development, sensitivity to loud sounds may be greater, as well as the level of damage[10].

The systematic and prolonged exposure to sounds with high sound pressure levels can a result in temporary or permanent change in hearing thresholds[11], the latter known as Noise Induced Hearing Loss (NIHL). This type of permanent damage may be the explanation for the high degrees of hearing impairment observed in children and adolescents, since the intensity of the ambient noises often approaches damaging levels[4,12].

In Brazil, the tolerance limits for continuous or intermittent noise postulated by the Regulatory Standard n. 15, by the Ministry of Labor[7] are recommendations for adult occupational exposure to noise and cannot be extended to the pediatric population. Thus, there are currently no standards of noise exposure time for children, and the incidence of temporary alteration of the hearing threshold or of NIHL is unknown in this population. In relation to toys, to be released for sale, they should be according to the Brazilian Standard (Norma Brasileira - NBR) 11786/92 – Toy Safety. This norm requires that the noise generated by toys, regardless of the age of the child, should not be greater than 85dB for continuous noise and 100dB for instant noise[13]. The toys nationally marketed should be certified by the National Institute of Metrology, Standardization, and Industrial Quality (Instituto Nacional de Metrologia, Normalização e Qualidade Industrial - Inmetro) complying with this rule.

The literature search conducted for this study showed that the most common studies are those related to noise exposure in intensive care units in hospitals, fireworks, music-related activities, as well as the school environment. However, some studies are now focusing on the effects of noise produced by toys in children[3-6,14-16]. In Brazil, investigations[17-19] have shown that toys have sound levels that could damage children's hearing, calling attention to the need for a preventive approach.

This study is justified by the fact that there is a large number of toys, with low cost, sold in the informal sector. It is known that, in these cases, most toys do not have control over sound levels. Thus, this study aimed to verify the sound pressure level produced by children's toys available in the informal sector retail trade.

Method

A cross-sectional observational research design was employed. The study selected toys offered at popular retail stores in the municipality of Porto Alegre, state of Rio Grande do Sul, Brazil, from the so-called informal sector. The inclusion criteria were having sound stimulus and not bearing a certification seal by Inmetro. All toys that met the criteria were included in the research until the estimated number was reached.

The sample size calculation was performed considering the values found in other studies[3-6,17,18], power of 90% and a level of significance of 5%. It was estimated the need for 40 toys to analyze the differences between the sound pressure

levels at different distances. We chose to increase the sample in 20%, in case there was need for exclusions.

Thus, 48 toys were evaluated, among electronic, mechanic and musical toys, including those that imitate real musical instruments and those who play recorded songs when some button is pressed. The toys were categorized by the presentation of the sound stimulus, followed by the classification of another similar study[18], in: emitting airflow (including wind), percussion, and electronics.

The measurement of each product was performed by the same acoustic engineer in an acoustically isolated booth, with a Lutron SL 4001 sound level meter and a Tectronix THS720 oscilloscope, with a Fonestar, FDM 283 unidirectional dynamic microphone. The measurements were performed according to the manufacturer. Data was collected with the Sound Level Meter set on slow-response circuit and compensation scale 'A' was used, according to recommendations[7]. The intensity was analyzed by the sound pressure level, in dB(A), and the frequency in hertz (Hz). For the parameters of sound intensity and frequency, the toys were played at a distance of 10 to 50 cm from the researcher's ear.

For statistical analysis of the data obtained, the Statistical Package for Social Science (SPSS) v.18.0 for Windows was used. Categorical variables were expressed as absolute frequency and relative frequency in percentages, and quantitative variables as mean, standard deviation, minimum, maximum, and confidence interval of 95% (95%CI). To compare the intensities emitted by toys at different distances, Student´s *t* test was applied. To verify the association between frequency and sound level pressure, the linear trend test was used. The level of significance was set at 5%.

Results

The frequency and intensity of the sound emitted by each toy, considering its category – airflow, percussion, electronic – are all presented in Tables 1, 2 and 3. The study assessed 17 airflow toys, 9 percussion toys, and 22 electronic toys.

Table 4 describes the mean sound intensity emitted by 48 toys, according to the category (airflow, percussion, electronics). Considering all 48 toys and the distance of 10cm from the ear, it was recorded a range of sound pressure of 102.1±10.1dB(A) (minimum 82.2dB(A); maximum 123.6dB(A); 95%CI 99.2–105dB(A)), and 47 (98%) toys were found to emit sounds above 85 dB(A). In measurements at 50cm from the ear, the mean sound pressure was 94±7.8dB(A) (minimum 79.2dB(A); maximum 108.6dB(A); 95%CI 91.8–96.3dB(A)), and 43 (89.6%) toys delivered sounds above 85dB(A). There were significant differences in loudness according to the distance (10 versus 50cm) in which the toy stood ($p<0.001$).

The resulting frequency spectra obtained in each toy was between 413 and 6635Hz. Among the 48 toys, 27 (56.3%) issued a frequency between 2030 and 6635Hz. It can be observed that the higher the frequency, the higher the sound pressure level and the higher the likelihood of presenting sound pressure levels above 85dB(A).

Table 1 - Frequency and intensity of the sound emitted by airflow toys, including wind instruments

Toy	Frequency (Hz)	Intensity [dB(A)] at 10cm	Intensity [dB(A)] at 50cm
Duck	6635	105.2	97.4
Swan	1108	112.3	102.5
Dog 1	1251	94.1	89.5
Dog 2	1642	103.6	94.7
Fish	3015	108.4	98.6
Rabbit	2531	89.5	86.2
Dolphin	835	88.1	85.2
Bear	3106	97.5	92.2
Cat 1	2230	101.2	96.2
Cat 2	3120	98.8	92.1
Frog	1560	92.5	89.2
Penguin	3230	101.2	98.6
Ball 1	604	109.4	102.3
Ball 2	1136	88.3	85.1
Flute	1605	107.2	100.4
Horn	2030	117.5	108.3
Apple	5002	113.3	103.5

Hz: hertz; dB(A): decibels on equalization curve 'A'.

Table 2 - Frequency and intensity of the sound emitted by percussion toys

Toys	Frequency (Hz)	Intensity [(dB(A)] at 10cm	Intensity [dB(A)] at 50cm
Rattle 1	413	102.3	91.6
Rattle 2	3333	96.4	92.4
Rattle 3	1280	101.1	98.8
Crib Rattle 1	502	94.5	88.3
Crib Rattle 2	2120	89.8	85.2
Harmonica	3750	110.8	104.7
Tambourine	3540	102.6	98.7
Xylophone	4230	98.8	96.8
Electric Guitar	4752	111.3	105.6

Hz: hertz; dB(A): decibels on equalization curve 'A'.

Table 3 - Frequency and intensity of the sound emitted by electronic toys

Toy	Frequency (Hz)	Intensity [dB(A)] at 10cm	Intensity [dB(A)] at 50cm
Car	2500	96.7	79.7
Race Car 1	2222	110	98.3
Race Car 2	4431	113.2	108.6
Police car 1	1250	123.6	98.9
Police car 2	5581	108.5	103.1
Car Steering Wheel 1	1054	96.4	91.3
Car Steering Wheel 2	714	92.3	86.7
Moto 1	1341	110.3	91.4
Moto 2	2886	112.1	103.8
Police Motorbike	2120	110.2	94.3
Fire Truck 1	1250	100.8	86.7
Fire Truck 2	4873	108.7	105.8
Police Truck 2	2502	119	86.7
Musical bus	2281	91.5	85.6
Helicopter	1667	118.2	96.5
Musical ladybug	1250	96.8	87.4
Musical Piano	1666	99.3	92.6
Robot 1	2501	110.1	81.5
Robot 2	3582	102.3	93.6
Super-Hero	2502	85.6	79.2
Phone 1	586	82.2	79.2
Phone 2	1125	92.3	84.3

Hz: hertz; dB(A): decibels on equalization curve 'A'.

Table 4 – Mean intensity of the sound, according to toy category

Type of toy	Intensity [dB(A)] at 10cm	Intensity [dB(A)] at 50cm	*p*
Airflow	100.8±10.2	96.2±6	<0.001
Percussion	100.8± 7.1	95.8±7	<0.001
Electronic	103.6±11.1	91.6±8.8	<0.001

dB(A): decibels on equalization curve 'A'.

Discussion

The finding that most toys emit sound pressure levels above 85dB(A) is consistent with other national[17-19] and international[3-6] surveys that have found similar results.

In a study conducted in the early 1990s[18], the values found for the wind instruments [78–123dbB(A)], electronics [103–119dB(A)], and percussion instruments [64–114dB(A)] are similar to the levels of the present study. It was found that the numbers today are not lower than 20 years ago, except for the maximum reading found in explosive toys [128–133dB(A)]. It is assumed that this is due to the fact that nowadays there are no more cap guns and 'firecrackers' available, which were responsible for such readings at the time.

Despite using different methodologies, especially in the distance analyzed, the findings of the present study corroborated two other studies, exceeding the recommended levels. In the international study[5], the authors found values between 95 and 126dB(A) at a distance of 2.5cm from the ear, and values between 88 and 115 dB(A) at a distance of 25cm. More recently, in a national study[17], using the same distance, the authors found that the measurements performed at 2.5cm from the ear ranged from 82–110dB(A), being 90% above 85dB(A), and the measurements made at 25cm ear ranged from 78–92dB(A), exceeding the intensity of 85dB(A) by 50%.

A recent study[19] compared the levels of noise emitted by certified toys with non-certified toys, showing that the toys without certification had significantly higher values of intensity, providing more risk factors for children's hearing.

For toys without the certification seal by Inmetro, such as the toys in the present study, the mean intensity was of 86.9±8.7dB(A) at a distance of 2.5cm from the ear, and 78.5±7.9dB(A) at 25cm. Even with different distances and without the division by kinds of toys, the values are lower than those recorded in the present research.

The aforementioned studies[5,17,19] demonstrated, as in this investigation, the increase in sound intensity with the proximity of the toy that makes noise; thus, the closer the child is to the toy, the more damaging to the auditory system. Another situation to be observed is that the noise exposure with possible repercussions on the auditory system do not only affect the child who handles toys, but also other children, once both at 10 and at 50cm the numbers were considered harmful.

In Brazil, the rules governing the release of the toys for sale are based on NBR 11786/92, according to which the noise generated shall not exceed 85dB for continuous noise and 100dB for instant noise[13]. It is noteworthy that the characteristic of most toys analyzed is having continuous emission of sound, being, therefore, considered unsuitable for handling by children due to the possibility of causing hearing damage.

Some studies[3,19] that assessed the noise levels produced by toys emphasized that noise intensity and frequency are important factors for changes in the auditory system. In the present study, more than half the toys presented a frequency above 2000Hz, almost all of them with pressure levels above 85dB(A), regardless of the distance from the researcher. These results suggest that, depending on the exposure time, there is a risk of hearing loss, affecting speech intelligibility. In this condition, for children in a period of learning oral language or in school age, distinguishing the sounds of the consonants can be a hard task, and may cause phonological changes due to a tendency to confuse the distinctive features of phonemes.

The consequences of noise exposure in childhood may be the installation of hearing loss, causing impairment in the acquisition of auditory skills, in addition to non-auditory effects, such as negative psychological responses to noise, changes in the performance of non-auditory tasks and in sleep[18].

The risk of developing NIHL is a serious threat to children's hearing health. Despite the existence of a Regulatory Standard for the sound output of toys, there are no parameters destined to the child population regarding safe amounts of hearing exposure. In order to do so, an extensive standardization research would be required that took into account mainly the hearing thresholds and sound pressure levels generated in the external auditory meatus of children, which are different from the parameters for the adult population.

Toys should fulfill their ludic role in a healthy way, provide child development through leisure, and there are no acceptable reasons for them to be noisy in a harmful way to children. In this context, there must be an awareness campaign aimed primarily at parents and educators about the effects of noise on children's hearing health, besides a more effective control by the regulatory agencies in order to prevent the selling of toys that emit high sound pressure levels.

In conclusion, the present study demonstrated that toys coming from the informal sector trade and without the certification seal by Inmetro presented a high level of sound pressure.

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