Sound Pressure Levels Measured in Fitness Gyms in Brazil

Karyn Lia Hamad Anjelo, *Paulo Henrique Trombetta Zannin
Laboratory of Environmental and Industrial Acoustics and Acoustic Comfort, Federal University of Paraná, Brazil
*Corresponding author

Résumé

Salles de fitness sont des lieux où les gens cherchent la santé et les loisir. Par conséquent, il est important de connaître les niveaux de pression sonore (SPL) généralement appliqués dans ces environnements. Cette étude a évalué l'éventail des niveaux de pression acoustique mesurée dans dix salles de fitness. Les mesures ont été prises au cours des séances de gym suivants: sauter, se balancer, localisée et l'exercice aérobie. Les mesures indiquées niveaux de pression sonore équivalent de 80 à 100 dB (A). Par conséquent, les niveaux de bruit générés actuellement dans les gymnases de l'échantillon dans cette étude, il ya certainement une possibilité de danger lié au bruit en milieu de travail.

Mots-clés: niveaux de pression acoustique, les mesures de bruit, gymnases, inconfort acoustique.

Abstract

Fitness gyms are venues where people seek health and leisure. Therefore, it is important to know the sound pressure levels (SPLs) usually applied in these environments. This study assessed the range of SPLs measured in ten fitness gyms. The measurements were taken during the following gym workouts: jumping, swinging, localized and aerobic exercise. The measurements showed equivalent sound pressure levels ranging from 80 to 100 dB(A). Therefore, with the noise levels currently generated in the fitness gyms sampled in this study, there is certainly a possibility of workplace noise hazard.

Keywords: sound pressure levels, noise measurements, fitness gyms, acoustic discomfort.

1 Introduction

Fitness gyms offer a wide variety of physical activities aimed at improving their users health and quality of life. This environment is characterized as occupational for the instructor and as a leisure environment for its patrons. Although the purpose of these gyms is to improve their users' physical fitness and health, these environments can also pose risks to both instructors and users. One of these risks comes from excessively loud music, since, according to Maia et al. [1].

As for the worker's health, it should be pointed out that work environments offer a variety of environmental and organizational risks that are responsible for triggering and increasing the prevalence and incidence of work-related diseases. Note that, among the environmental and occupational health risks, noise is currently considered the most common physical agent in workplaces [2, 3].

According to Costa et al. [4], high noise levels in Brazil are increasingly related to leisure activities, be it through excessively loud music, motor sports, or sports shooting. Fitness gyms offer a wide variety of sports activities aimed at improving the quality of life of their patrons. Notwithstanding the concept of a better quality of life and the pursuit of a healthier life, this environment may also pose health risks to both professionals and users. One of these risks comes from the use of excessively loud music, since, as Maia et al. [5] point out, although music is pleasurable, it can be harmful to hearing and hence to the quality of life when presented at high sound pressure levels. Regarding the use of music in fitness gyms, Zucki and Lacerda [6] argue that it has become a common practice, since patrons and personal trainers believe it stimulates physical activity, making it more enjoyable and thus enhancing performance.

Given the importance of the theme of leisure activity linked to fitness gyms, this study documented noise levels normally found in such environments. To this end, sound levels were measured in ten fitness gyms in the city of Curitiba, in southern Brazil.

2 Materials and Method

The sound pressure levels (SPLs) in the 10 fitness gyms were measured during the following gym workouts: jumping, swinging, localized and aerobic exercise. The SPLs were measured with a class I Brüel & Kjaer 2238 sound level meter. Measurements of the equivalent continuous sound pressure level, Leq, were taken for 40 minutes and A-weighted, because this is the duration of a workout session with loud music. The last 10 minutes of each session are for relaxation, and are usually accompanied by very low or no music. Therefore, SPLs were not measured during the last 10 minutes of workout sessions. The sound level meter was placed on a tripod at a height of 1.20 m from the floor.

*paulo.zannin@gmail.com

Fitness gyms are a work environment for physical education instructors and a leisure environment for patrons. The noise levels measured in the fitness gyms were characterized according to the guidelines of Regulatory Standard NR 15 of the Brazilian Ministry of Labor and Employment, which establishes guidelines for managing occupational noise in the country [7]. According to Brazil's NR 15 standard, "*Noise measurements should be taken close to the worker's ears.* "

Table 1 list the limits established by NR 15 [7] for workplace noise levels, and the resulting maximum permissible length of stay of workers in these environments. The NR 15 standard establishes an equivalent sound level, Leq, of 85 dB(A) as the reference level to which a worker may be exposed during a standard 8-hour work day. An 8-hour workday at a noise level of 85 dB(A) corresponds to 100% of the daily noise dose. If this daily noise dose is exceeded, the employee is entitled to receive additional compensation over and above his salary. Brazil's NR 15 standard uses an exchange rate of *q*=5. Table 2 describes the permissible noise levels for fitness gyms.

Table 1: Limits of tolerance to daily occupational noise exposure – NR 15 standard

Noise levels Leq dB(A)	Maximum permissible daily exposure time (*Te*)
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours and 30 min
90	4 hours
91	3 hours and 30 min
92	3 hours
93	2 hours and 40 min
94	2 hours and 15 min
95	2 hours
96	1 hour and 45 min
98	1 hour and 15 min
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

Table 2: Spatial volume of the fitness gyms

Fitness Gym	Volume [m^3]
G1	259.09
G2	249.80
G3	124.33
G4	252.84
G5	393.24
G6	258.74
G7	202.00
G8	228.19
G9	279.65
G10	449.38

The noise dose [8] is calculated by the following expression [1]:

$$D = (Te/TE)\, x 100 x 2^{\frac{NE-85}{q}} \qquad [1]$$

where: *D* [%] is the daily noise dose; *Te* is the duration of exposure, in minutes, during a workday; *TE* is the duration of the standard workday, which in Brazil is *TE* = 480 minutes (or 8 hours); *NE* is the equivalent sound level measured during the workday, *Te*; and *q* is the exchange rate, which, in Brazil, is equal to *q =5*.

Figures 1 to 10 show the layout of the fitness gyms evaluated in this study. Computer simulations were performed using Odeon Combined version 9.2 software to evaluate the acoustic quality of the fitness gyms and measure their reverberation time, RT [9]. An OmniSource™ Type 4295 single speaker omnidirectional sound source (Brüel & Kjær) was used to calculate the RT. A grid was designed with receivers positioned in a 10x10 centimeter mesh for all the fitness gyms. Table 3 describes the RT of the fitness gyms.

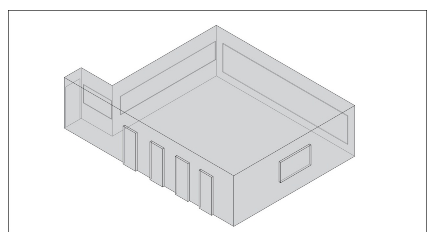

Figure 1: Layout of fitness gym G1

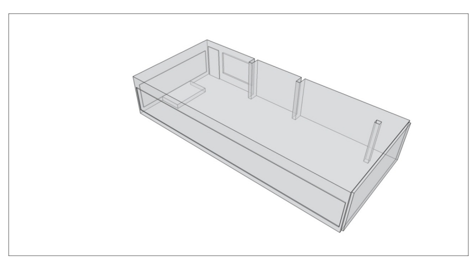

Figure 2: Layout of fitness gym G2

Fitness gym G1 has a concrete ceiling and ceramic tile flooring. G2 has a PVC ceiling tiles and wooden flooring. G3 has a wooden ceiling and ceramic tile and wooden flooring. G4 has a PVC ceiling tiles and wooden flooring.

G5 has a wooden ceiling and flooring. G6 has a wooden ceiling and rubberized flooring. G7 has a concrete ceiling and rubberized flooring. G8 has a concrete ceiling with rockwool insulation and wooden flooring. G9 has a concrete ceiling and granite floor tiles. G10 has a concrete ceiling and ceramic floor tiles.

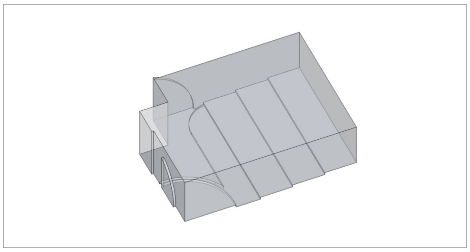

Figure 3: Layout of fitness gym G3

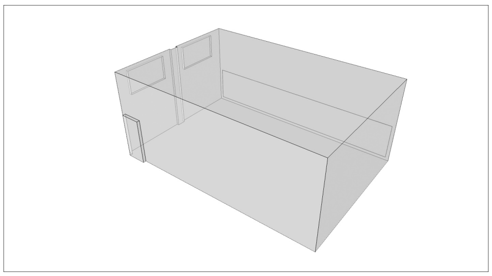

Figure 4: Layout of fitness gym G4

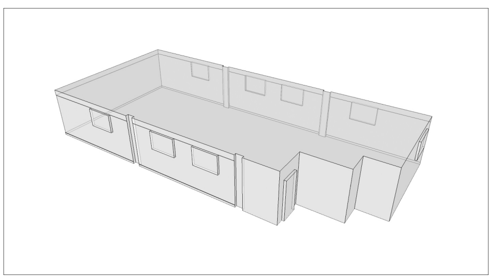

Figure 5: Layout of fitness gym G5

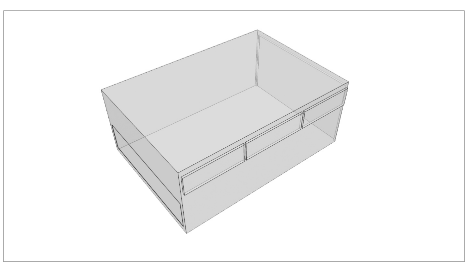

Figure 6: Layout of fitness gym G6

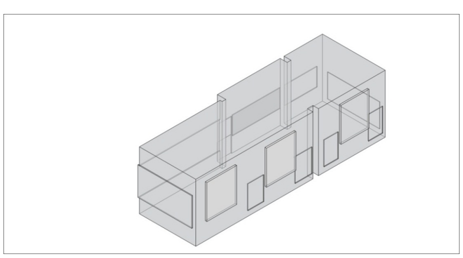

Figure 7: Layout of fitness gym G7

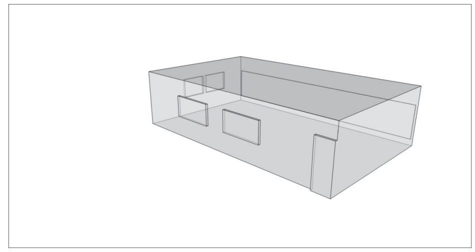

Figure 8: Layout of fitness gym G8

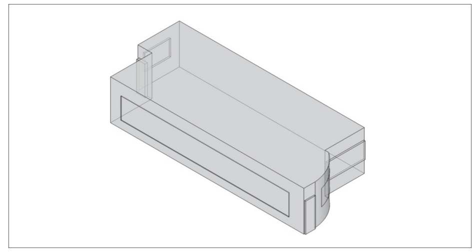

Figure 9: Layout of fitness gym G9

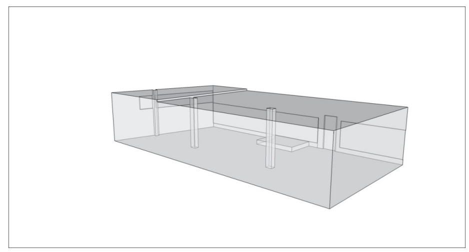

Figure 10: Layout of fitness gym G10

Table 3: RT of the fitness gyms

Fitness Gym	RT [s]			Mean RT [s]
	500 Hz	1 kHz	2 kHz	
G1	5.9	4.5	3.8	4.7
G2	2.6	2.5	3.4	2.8
G3	1.4	1.7	2.3	**1.8**
G4	2.4	1.7	2.9	2.6
G5	1.5	2.1	2.0	**1.9**
G6	1.4	1.8	2.1	**1.8**
G7	3.9	3.7	3.0	3.5
G8	0.6	0.9	1.0	**0.8**
G9	4.9	4.2	3.5	4.2
G10	6.5	5.4	4.7	5.5

3 Results and Discussion

The RT of the gyms was calculated using Odeon version 9.2 software [9]. The mean RT was calculated as the arithmetic mean of the respective reverberation times at frequencies of 500 Hz, 1 kHz and 2 kHz, according to Ananthaganeshan and Gastmeier [11]. These authors suggest that the mean RT of unoccupied gyms is between 1.5 and 2.0 seconds, at frequencies of 500 Hz, 1 kHz and 2 kHz. According to them, an RT value within this range would represent a compromise between an environment destined for sports practices and/or musical performances and speech intelligibility [11]. The literature consulted for this study does not report RT data for fitness gyms. Therefore, we used the data presented by Ananthaganeshan and Gastmeier [11] as a reference to evaluate the RT of the fitness gyms of this study.

Considering the average RT of 1.5 to 2.0 s suggested by Ananthaganeshan and Gastmeier [11] to provide an environment conducive to physical activity, with music as the main catalyst, it was found that, among the ten fitness gyms, only G3, G5 and G6 (see Table 3) were within this range, while the others exceeded the upper limit of the suggested range of RT values. The only exception was G8, whose RT was 0.8 s, i.e., below the range of suggested values [11]. Fitness gym G8 has a concrete ceiling with rockwool insulation and a rubberized floor (see section 2).

In the particular case of the academy A8, RT simulation was performed with the removal of Rock-wool layer that covered the ceiling, and the inclusion in one of the walls of a plasterboard perforated panel [12]. Figure 11 shows the changes made in the gym A8:

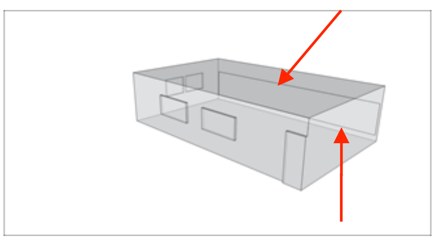

Figure 11: Fitness gym G8

Table 4 lists the sound absorption coefficients used to calculate the new RT for fitness gym G8.

Table 4: Sound absorption coefficients (α) as a function of frequency – Fitness gym G8.

Material	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Rock-wool [12]	0.09	0.29	0.55	0.61	0.82	0.91
Heavy rough concrete surfaces [12]	0.02	0.03	0.03	0.03	0.04	0.07
Plasterboard perforated panel [12]	0.33	0.79	1.03	0.83	0.65	0.54

With perforated plasterboard ceiling and wall paneling, the simulated RT of gym G8 was 1.3 s, 1.4 s and 1.7 s, respectively, at the frequencies of 500 Hz, 1 kHz and 2 kHz, and the mean RT was 1.5 s, i.e., within the 1.5 to 2.0 s limit proposed by Ananthaganeshan and Gastmeier [11].

Table 5 lists the equivalent sound pressure levels Leq measured in the 10 fitness gyms, and the daily noise dose. The calculated noise dose refers to the duration of a workout session, which is *Te* = 40 minutes. Brazil's aforementioned NR 15 standard considers that, for a normal 8-hour workday, the sound level of reference is Leq = 85 dB(A), and the noise dose of reference is 100%. In Table 5, note that the daily noise dose, D, did not exceed 100% in any of the workout sessions evaluated in the fitness gyms. Therefore, the gyms fall within with the D reference value of the NR 15 standard.

Table 5: Equivalent continuous sound level measured in each fitness gym, and daily noise dose for a 40-min workout session and for an average daily exposure time of 3 hours.

Fitness Gym	Equivalent Sound Level, L_{eq} dB(A)	Daily noise dose D (%) *Te* = 40 min (duration of a session)	Daily noise dose D (%) *Te* = 3 h (or 180 min) (mean daily exposure time)
G1	92	22	99
G2	87	11	50
G3	89	15	65
G4	86	10	43
G5	80	4	19
G6	82	6	25
G7	94	29	131
G8	99	58	261
G9	100	67	300
G10	88	13	57

However, in her master's dissertation, Anjelo [10] applied a questionnaire to assess the working conditions of the instructors of the fitness gyms under study. The group of instructors comprised 10 individuals (one for each fitness gym), 7 women and 3 men, with an average age of 28 years. The average time of professional activity is approximately 8 years. The average weekly workload at the evaluated gyms, from Monday to Friday, is 15 hours, corresponding to a average daily workload of 3 hours per instructor per gym. Thus, considering this average daily workload, Table 1 shows that the allowed limit noise level is 92 dB(A). Table 5 shows that the noise level measured in gym G1 was 92 dB(A), so an average exposure time of 3 hours/day corresponds to a noise dose of 99%. Although this value is high, it does not exceed the noise dose limit of 100%. However, an aggravating factor of this situation is that the RT in gym G1 is 4.7 s, the second highest RT among the ten gyms (see Table 3).

As can be seen in Table 5, considering the average daily exposure time of 3 hours at the other gyms, the daily noise dose of 100% was exceeded in gyms G7, G8 and G9. The calculated noise dose was 131% in G7, 261% in G8, and 300% in G9, significantly exceeding the 100% daily noise dose limit established by the NR 15 standard. A factor that aggravated this situation was that gyms G7 and G9 presented RTs of 3.5 and 4.2 s, respectively, i.e., well above the limit RT of 1.5 to 2 s suggested by Ananthaganeshan and Gastmeier [11].

4 Conclusions

This study documented the noise levels and daily noise dose in ten fitness gyms in Brazil, and also evaluated their RTs.

As Angelo [10] reported, the average daily workload per instructor at each of the evaluated fitness gyms is 3 hours. This means that the daily noise dose is 99% in gym G1, 131% in G7, 261% in G8, and 300% in G9. Only three fitness gyms, G3, G5 and G6, showed reverberation times within the 1.5 to 2 s limit suggested by Ananthaganeshan and Gastmeier [11]. It should be noted that the gym instructors work at other fitness gyms, thus extending their daily workload. Given these facts, therefore, it can be concluded that with the noise levels currently generated in the fitness gyms sampled in this study, there is certainly a possibility of workplace noise hazard.

Acknowledgments

The authors gratefully acknowledge the financial support of the Brazilian Government, through the National Council for Scientific and Technological Development – CNPq, and the German Government, through the German Academic Exchange Service – DAAD, which enabled the purchase of the equipment and software used in this study. The authors also wish to thank the anonymous reviewers for their careful assessment and invaluable suggestions.

References

[1] J.R.F. Maia, I.C.P. Russo. Estudo da audição de músicos de rock and roll. [*Study the hearing of rock and roll musicians*]. *Pró-Fono Revista de Atualização Científica*, 20(1):49-54, 2008. (in Portuguese).

[2] E.C.G. Matos. Incômodo decorrente do ruído na escola em professores com e sem distúrbios vocais. [*Discomfort caused by noise in school for teachers with and without voice disorders*] Pontifícia Universidade Católicado Paraná, 2008. Master's Dissertation (in Portuguese).

[3] C.G.O. Gonçalves.Saúde do Trabalhador – da estruturação à avaliação de programas de preservação auditiva. [*Worker Health – from the structuring to the evaluation of hearing preservation programs*] São Paulo: Editora Roca, 2009 (in Portuguese).

[4] E.A. Costa, T.C. Morata and S. Kitamura. Patologia do ouvido relacionada com o trabalho. [*Work-related hearing pathology*] In: Patologia do Trabalho. Mendes R. [Ed]. São Paulo, Atheneu, 2003 (in Portuguese).

[5] A.A. Maia, D.U. Gonçalves, L.M. Menezes, B.M.F. Barbosa, O.S. Almeida andL.M. Resendo. Análise do perfil audiológico dos músicos da Orquestra Sinfônica de Minas Gerais (OSMG). [*Analysis of the audiological profile of the musicians of the of Minas Gerais Philharmonic Orchestra (OSMG)*]. *Per Musi – Revista Acadêmica de Música*, Belo Horizonte, **15**: 67-71, 2007 (in Portuguese).

[6] F. Zucki and A.B.M. Lacerda.O ruído em atividades de educação física. [*The noise in physical education activities*] In: Morata TC, Zucki F. [Ed] Saúde Auditiva – Avaliação de Riscos e Prevenção. [*Hearing Health - Risk Assessment and Prevention*] São Paulo: Plexus, 2010 (in Portuguese).

[7] NR – 15 - Norma Regulamentadora NR-15 – Atividades e operações insalubres, Anexo 1 [*Regulatory Standard NR-15 – Unhealthy activities and operations, Appendix 1*]. Segurança e Medicina do Trabalho [*Safety and Occupational Medicine*], Editora Atlas, São Paulo; 68th ed., 2011 (in Portuguese).

[8] NHO-01 – Norma de Higiene Ocupacional – Procedimento Técnico – Avaliação da Exposição Ocupacional ao Ruído, Fundacentro, São Paulo, 1999.

[9] ODEON – Software Handbook, Version 9.2.

[10] K.L. Hamad-Anjelo. Avaliação do ruído e da qualidade auditiva de professores de academias de ginástica. Universidade Federal do Paraná. 2013. Master's Dissertation (in Portuguese).

[11] K.A. Ananthaganeshan and W.J. Gastmeier. Acoustical Performance Criteria, Treatment and Guidelines for Multifunctional School Gymnasia. *Canadian Acoustics*, 35 (4): 25-30, 2007.

[12] H. W. Bobran and I. Bobran-Wittfoht. Handbuch der Bauphysik. 7 völlig neubearbeitete Auflage. Friedr. Vieweg & Sohn Verlagsgesellschaft mbH, 1995 (in German).