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Measurement of sound level in sports clubs with the approach of maintaining the health of athletes

Ling-Hsiang Chang[1], Hooman Bahmanpour[2*], Ali Fahiminejad[3]
1- Graduate Institute of Tourism Management, National Kaosiung University of Hospitality and Tourism Nationality, Taiwan, China
2- Assistant Professor, Department of Environment, Faculty of Engineering, Shahrood Branch, Islamic Azad University, Shahrood, Iran
2- Assistant Professor, Department of Physical Education, Faculty of Human Sciences, Shahrood Branch, Islamic Azad University, Shahrood, Iran
*Correspondence author: hooman.bahmanpour@yahoo.com

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Abstract: The purpose of this study is to measure the sound level in bodybuilding clubs in Mashhad with the approach of maintaining the health of athletes. The metropolis of Mashhad, the capital of Khorasan Razavi province, is located in northeastern Iran. Fifteen bodybuilding clubs were randomly selected by networking method. The sound level in the clubs was measured in level A and as an equivalent level by the portable device and software Decibel X version 2019 and was compared with the sound standard (OSHA-90 dBA). Measurements were made in the morning and evening. The parameters of sound pressu

The lowest sound pressure level in the morning was 76.5 decibels and the highest pressure level in the evening was 99.4 decibels. There was a direct relationship between sound pressure level and athletes' time in the club. The average sound level in sports clubs is equal to 87.6 dB and the level is equal to 90.61 and the daily individual dose of LEp, d athlete in the club is equal to 84.58 dB. The permissible duration of exposure to noise for athletes was estimated at 1 hour and 40 minutes. In the gymnasiums of Mashhad, athletes are exposed to high noise pollution and the possibility of physical and mental injuries is high. The existing sound levels are higher than the global and national standards and indicate that the use of engineering and management measures to reduce the sound level in fitness clubs is mandatory. Insulation of equipment, walls and floors can be used to reduce the sound level in gyms. Also, the

Introduction

One of the important concerns of sports organizations is the standardization of sports environments in terms of health, safety and environment. In recent years and in numerous studies, the effect of various environmental pollutants on the health and efficiency of athletes has been studied and evaluated (Rabani et al., 2020). One of the types of environmental pollutants is noise pollution. Due to the fact that noise pollution is not visible, it has the ability to negatively affect concentration, nerves, efficiency and ultimately people's health (Monazzam et al., 2010). For this reason, today, many instructions have been published by specialized organizations to reduce and control the sound level in industrial and office places, as well as recreation and sports. Physical activity and sports are one of the most important components of life. The noisier the outdoor space, the lower the quality of life of residents and the less inclined people are to engage in physical activity. New research shows that living in noisy areas reduces residents' exercise rates (Taheri et al., 2019). Although sound waves are considered as an essential factor in human life, in some cases they are not pleasant. Exposure to excessive noise higher than the limits can cause annoyance and hearing loss in human (Agrawal et al., 2010). Noise pollution is defined as the

propagation of sound and vibration higher than the allowed limits in open spaces (outdoors) and is one of the examples of environmental damages (Vogiatzis, 2012) and has obvious consequences on human health and ecosystems (WHO, 2011). Exposure to sound not only occurs in work environments but also includes non-occupational activities such as recreation times, transportation, shopping, etc. (Clark et al., 2013). Noise pollution has a significant role in dissatisfaction with area (Parkes et al., 2002). Reducing outdoor sound pollution, if desirable for most users, determines acoustic comfort (Yang & Kang, 2005). Noise as a general stressor can affect the cardiovascular system and causes nervous simulation, anxiety, mental and psychological problems (Bazaras, 2006). In some studies, sound effects as a stressor factor has been studied and noise pollution mentioned as a dangerous factor for human health (Zannin et al., 2003). The stress caused by noise pollution is inherently psychological (Sommerhoff et al., 2004; Babisch et al., 2013). Also; Exposure to sound can affect a person's efficiency, especially in mental tasks (Dobie, 1999). In general, it can be said that not only noisy environments causes disorders in communication and conversations, but also carelessness in brain activities and inconsistency of thinking activities. Furthermore, learning is reduced and the number of mistakes will be increased. Due to loud and sudden sounds which cause stress and fear, blood pressure, especially the pressure inside the skull increases, salivary secretions decreases and the mouth becomes dry (Babisch & Van Kamp, 2009). According to studies of World Health Organization and International Labor Organization, signs of physiological effects related to noise pollution in human are shown at the level of 30-60 dB, Also, severe physiological complications and diseases caused by that occur in higher levels and 85-120dB (Arsalan et al., 2002; Hassmen & Koivula, 2001). Exposure to higher levels can cause traceable effects or physiological measurements on the body which are called strain or tension. Here, in addition to the mental effects of changes in the nervous and brain waves, changes in blood pressure and heart rate, hardening of the vascular wall and changes in some hormones such as adrenaline and cortisol can be measured (Hansell et al., 2013).

According to the World Health Organization (WHO) reports, exposure to sound pressure level of 80 dB can cause aggressive behaviors. Noise pollution in higher sound pressure levels (more than 85 dB) causes direct effects on hearing organs, including Temporary Threshold Shift (TTS) and long term contacts cause Permanent Threshold Shift (PTS). According to medical surveys, signs of hearing power reduction were seen in those who have been exposed to a sound with the intensity of 80 dB (Stansfeld et al., 2000; Evans & Hygge, 2007). Disorders of the digestive system and increase in cholesterol and triglycerides and diabetes are the consequences of exposure to sound (Evans & Hygge, 2007).

Exposure to noise in the long term can cause hearing harms which individuals might not be aware of it (Blanchfield et al., 2001; Vogel et al., 2007; Muhr et al., 2007; Sorensen et al., 2007). Fig 1 which is called sound effects pyramid shows the noise pollution consequences based on two parameters of severity and the number of people exposed to it. In recent years, noise pollution and its consequences has become an important issue in scientific researches and numerous studies have been conducted to reduce the noise pollution problems in different cities and human settlements (WHO, 2011; Babisch et al., 2009; Abbaspour, 2016; WG-AEN, 2007), It is more than two decades that water, soil and air pollution have been considered in Iran but still needs much efforts in noise pollution (Ghanbari et al., 2011; Fataei et al., 2011). While the increase of different urban activities has led to reveal the sound pollution as a social problem, but the importance of noise pollution in the country is not clear.

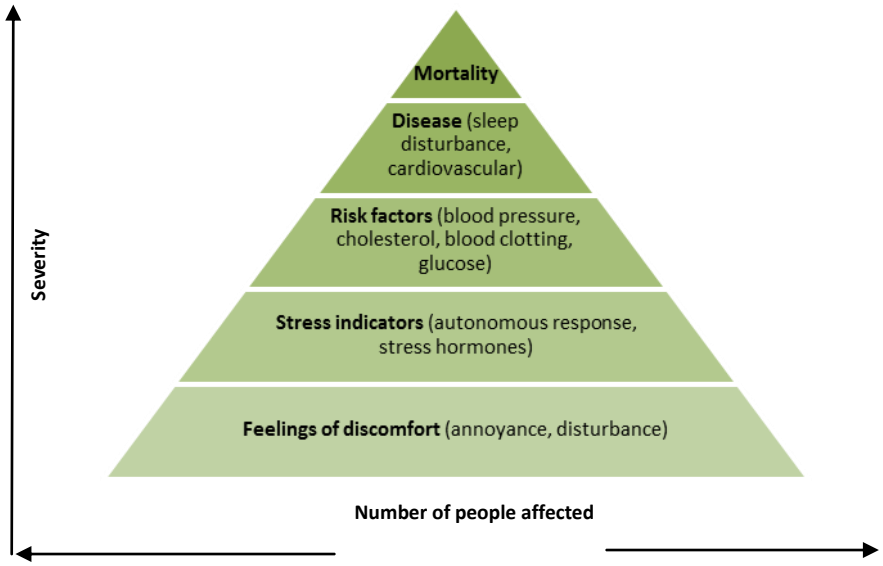

Fig. 1- Sound effects pyramid (Karimi et al., 2011)

Noise pollution is monitored in three different fields: (1) Traffic and transportation, (2) Industrial activities, and (3) Sport, business and recreational areas. It has been clearly defined that noise pollution is a potential problem for health, communication and social life enjoyment (Sukru et al., 2006). Numerous studies have been shown that exposure to recreational intense sounds increases the damages of hearing system (Clark, 1991; Dalton et al., 2001). Living in areas with high noise reduces the possibility of residents' exercising (Tin & Lim, 2000; Bahmanpour et al., 2011). Noise also affects sleep quality which has a direct impact on one's tendency towards exercising. Lack of physical activity and exercising is one of the problems of modern society and researches are seeking for a way to overcome it. Reducing noise pollution in cities and terrific volume can be helpful in overcoming this problem. One of new approaches in sport management is sustainable sport management which benefits all the groups such as the public, athletes, and environmental activists. Sport can be universal, fruitful, and environmentally and socially sound (IOC, 2000).

Sport activities can be called sustainable and healthy if guarantee psychological and physical health of the users (Chernushenko et al., 2000). One of the environmental principals of Olympic Coordination Authority (OCA) is commitment to minimize the sound impacts on the environment and neighboring residential areas (IOC, 2000).

Based on the standards of Iranian Department of the Environment, the limits of equivalent sound pressure level for the residential area from 7 a.m. to 10 p.m. and is 10 p.m. to 7 a.m. is 55 and 45 dB, respectively (OEL, 2017; Karimi et al., 2011). The standard of US Environment Protection Agency (EPA) for sound volume in open spaces (game grounds) is between 55 and 70 dB (EPA, 2014). The standards of England for parks and recreational areas (A) are 55 dB. According to some international standards and studies, sound pressure levels in sport areas should not be more than 55 dB and the sound higher than 85 dB has the ability to hurt the hearing system (Dursun & Ozdemir, 1999). The sound level for open and public spaces should not be more than 85 dB based on WHO (WHO, 2011). Some of the noise pollution standards related to the research topic are shown in Table 1.

Table 1- International standards in the field of noise pollution

Source	Standard	Description
DOE	55-45 dB	From 7 a.m. to 10 p.m. and is 10 p.m. to 7 a.m.
USEPA	55-70 dB	In open spaces (game grounds)
The standards of England for parks and recreational areas	55 dB	cause aggressive behaviors
Dursun & Ozdemir, 1999	Not be more than 55 dB and the sound higher than 85 dB	Sound pressure levels in sport areas
WHO, 2011	Not be more than 85 dB	The sound level for open and public spaces

The purpose of this study is to measure the sound level in sports clubs. This sport always welcomes a large number of users (professionals and amateurs) who, due to the multiplicity and variety of

activities, tools and equipment, seem to have a high level of sound level, which will increase the risk of injury.

2. Materials and Methods

This is a cross-sectional study and the data has been obtained by field research. Data analysis is analytical and comparative comparison carried out with the national and international standards. The statistical population was bodybuilding clubs in Mashhad. For this purpose, first the city of Mashhad was divided into 5 regions and then from each region, 3 sports clubs and a total of 15 cases were randomly selected (Figure 2). Data were extracted by field sampling.

The sound level on athletes' route in one metre distance, in A level and as an equivalent level was measured by a portable device and Decibel X software (Version 2019) and compared with the standard sound (OSHA-90 dBA). In evaluating the sound process, the sound level metre microphone was at least 3 metres away from reflective surfaces (such as walls) and 1.5 metres away from the ground (Dursun & Ozdemir, 1999). Also, a distance equals to the length of an arm from the operator's body was considered. It should be noted that the error of up to 6 dB is negligible while evaluating (Ringen, 1994). The measurement time at each station was 30 minutes (based on standards of Open Air by Iranian DOE), each was repeated two times. The first and second measurement was carried out on 10-10:30 AM, 7-7:30 PM and 12-12:30 PM, respectively. It should be noted that in the sound level measurements, the turn and time sequence of men and women using sports space was considered.

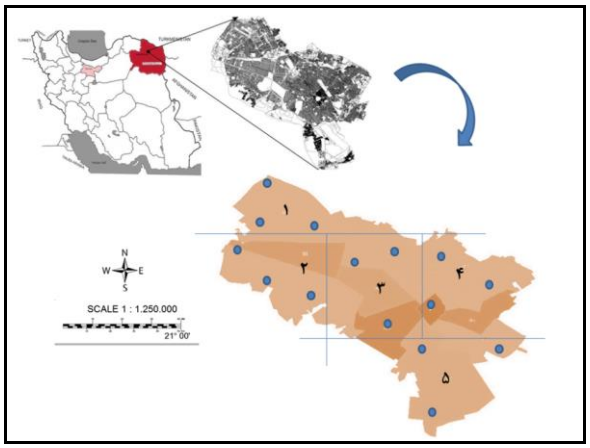

Fig. 2- Mashhad city division and location of selected sports clubs to measure sound level (Authors, 2019)

In this research, sound pressure level parameters (LP or SPL), average sound level ($\overline{LP}$), equivalent continuous sound level (Leq) and personal daily dosage $L_{AEp,d}$ were calculated. First, at each station the sound pressure level (dBA) was measured by a portable device based on the following relation and was recorded in the table (South, 2004).

Relation (1)

$$SPL(dB) = LP = 10\,log\left(\frac{P^2}{P_0^2}\right) = 20\,log\left(\frac{P}{P_0}\right)$$

$$SPL = 20\,log\,P + 94$$

In the above relation, P is the absolute sound pressure in the measurement point and P_0 is the basic pressure which equals to 2×10^{-5} Pascal (PA).

Due to the logarithmic nature of the sound pressure levels, it is not possible to directly apply math operations such as addition, subtraction, or averaging. Therefore, the average sound level in the studied route is estimated from the following equation :(OEL, 2017)

Relation (2)

$$\overline{LP}\,(dB) = 10\log\left[\frac{1}{n}\times\sum_{i=1}^{n}10^{\frac{LPi}{10}}\right]$$

In this relation, *n*: is the number of measurement points and *LPi*: sound pressure level on each point. Since the athlete is exposed to various levels of sound pressure during climbing, an equivalent level of sound exposure (dBA) Leq is used for accurate assessment. The following relation shows the calculation method (Golmohammadi, 2010):

Relation (3)

$$L_{eq}(dB) = 10\,log\left[\frac{1}{T}\sum_{i=1}^{n}t_i\,10^{LP_i/10}\right]$$

In this relation, LP_i is the sound pressure level in time t_i with equal units (in hours, minutes, or seconds) and T is the reference time. Also; personal daily dosage of an athlete was calculated from the following relation (South, 2016):

Relation (4)

$$LEp,d = Leq + 10\,log\frac{t}{m}$$

In the above relation, Leq is the equivalent sound exposure level, t: the duration of athlete presence in the region, and m: the maximum time of exposure to noise pollution in according to International Labour Organization standards and is equal to 8 hours.

According to the interview with the athletes, the average time spent on one day in bodybuilding club is 2 hours. Using the standard published by the Health and Safety Executive on sound reductions in workplaces (South, 2016), the maximum exposure time limit was calculated for athletes in clubs.

3. Results

Sound pressure level (dBA) was measured and recorded in every clubs at different times. Also, the average sound level in each station and every time was calculated (table 2).

Table 2- The average 30-minutes sound pressure level in weighted network Leq (30 min) db (A) in two times intervals in selected sport clubs

Station No	First time 10-10:30	Turn to use	Second Time 19-19:30	Turn to use	The average sound level in each station
1	77.8	Men	81.4	Men	79.6
2	79.1	Women	83.2	Women	81.15
3	76.5	Men	84.5	Men	80.5
4	80.2	Men	88.5	Men	84.35
5	79.6	Men	85.7	Women	82.65
6	82.7	Men	88.9	Men	85.8
7	83.3	Women	90.5	Men	86.9
8	78.8	Women	84.7	Women	81.75
9	86.8	Men	92.5	Men	89.65
10	90.3	Men	97.7	Men	94
11	82.2	Men	88	Men	85.1
12	80.3	Women	87.6	Women	83.95
13	85.5	Men	86.1	Men	85.8
14	90.3	Men	99.4	Men	94.85
15	83	Women	89.6	Men	86.3
average	82.42	-	88.55	-	85.49

(Source: Research finding)

As can be seen, the lowest sound pressure level measured was 76.5 decibels in the first time and at the time of men's use at Sports Club No. 3. Also; the highest measured sound pressure level belonged to Sports Club No. 14, in the second time and the time of use of men was equal to 99.4 decibels.

On the other hand, the measured sound pressure level shows that the average sound pressure level increases in proportion to the change of time from early morning (10 am) in night (7 pm). In other words, there is a direct relationship between sound pressure level and the time of athletes in the club (Figure 3).

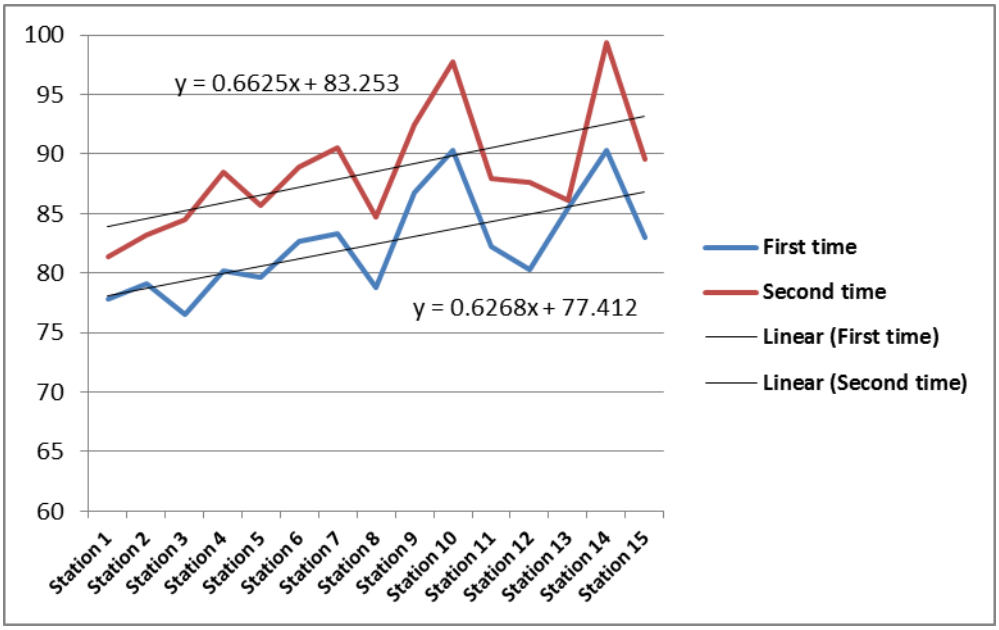

Fig. 3- Comparative diagram of measured sound pressure level Leq (30min) dB (A) in Bodybuilding clubs in separate turns
(Source: Research finding)

In total, the lowest average sound level belongs to Station (Club) No. 1 with 79.6 decibels and the highest average sound level belongs to Station No. 14 with 94.85 decibels. Figure 4 shows a graph of the average sound level in the bodybuilding clubs of the study area, compared to international standards.

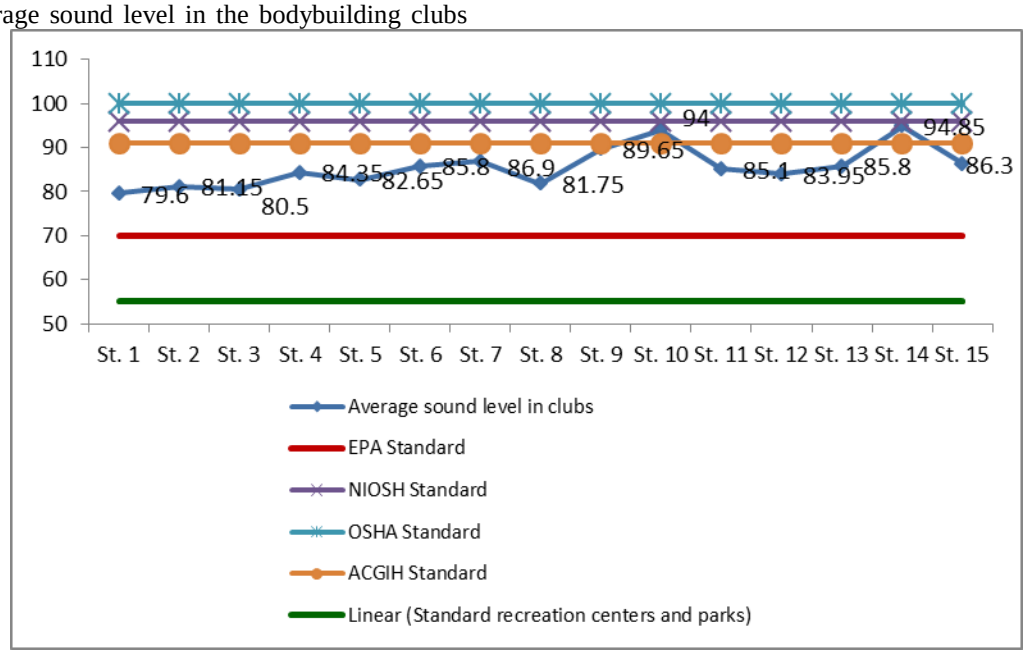

Fig. 4- Comparative diagram of average sound level dB (A) measured in bodybuilding clubs with international standards
(Source: Research finding)

According to the diagrams for the sound intensity level in the study area (Figure 5), it can be concluded that the emitted sound field is of free type and since the sounds did not interrupt during the propagation time, they are of continuous type which is more detailed in segmentation. Because pressure level changes over time are between 5-15 decibels, they are also in the category of time-varying sounds.

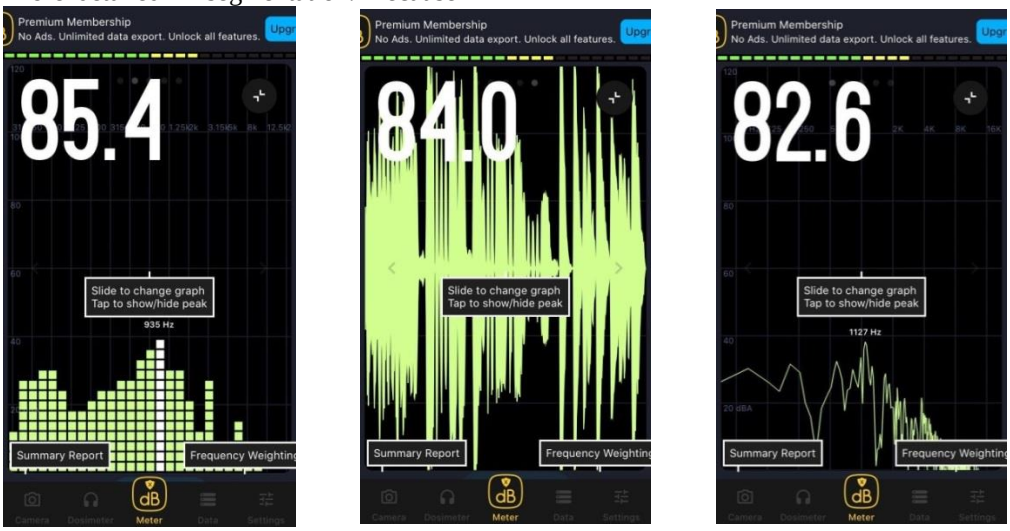

Fig. 5- Some examples of SPL (dBA) sound level diagrams in measuring stations
(Source: Research finding)

Using Equation (2), the average sound level in sports clubs was calculated to be 87.6 dB.

$$\overline{LP}\,(dB) = 10\log\left[\frac{1}{n}\times\sum_{i=1}^{n}10^{\frac{LPi}{10}}\right] = 87.6\,dB$$

Then, through Equation (3), the equivalent level of sound exposure (dBA) Leq was estimated. According to interviews with athletes, the average time spent on a sports day in a club is 2 hours. Based on this, the balance is estimated at 90.61 decibels.

$$L_{eq}(dB) = 10\ log\left[\frac{1}{T}\sum_{i=1}^{n} t_i\ 10^{LP_i/10}\right] = 90.61\ (dB)$$

Using Equation (4), the individual daily dose of LEp, d for an athlete in the club is 84.58 dB:

$$L_{Ep,d} = Leq\ + 10\log\left(\frac{t}{m}\right)$$

$$L_{Ep,d} = 87.69\ + 10\log\left(\frac{6}{8}\right) = 84.58(dB)$$

In order to determine the allowable time of exposure to sound in the study environment, HSE nomogram was used. Accordingly, according to the obtained equivalent balance which is equal to 90.61 decibels and also the daily dose of the individual which was equal to 84.58 decibels, it is possible to calculate the time allowed for exposure to noise in gyms for athletes which is equal to 1 it is an hour and 40 minutes (Figure 6). Therefore; it turns out that the average time spent by athletes in this area is about 20 minutes longer than the allowable time.

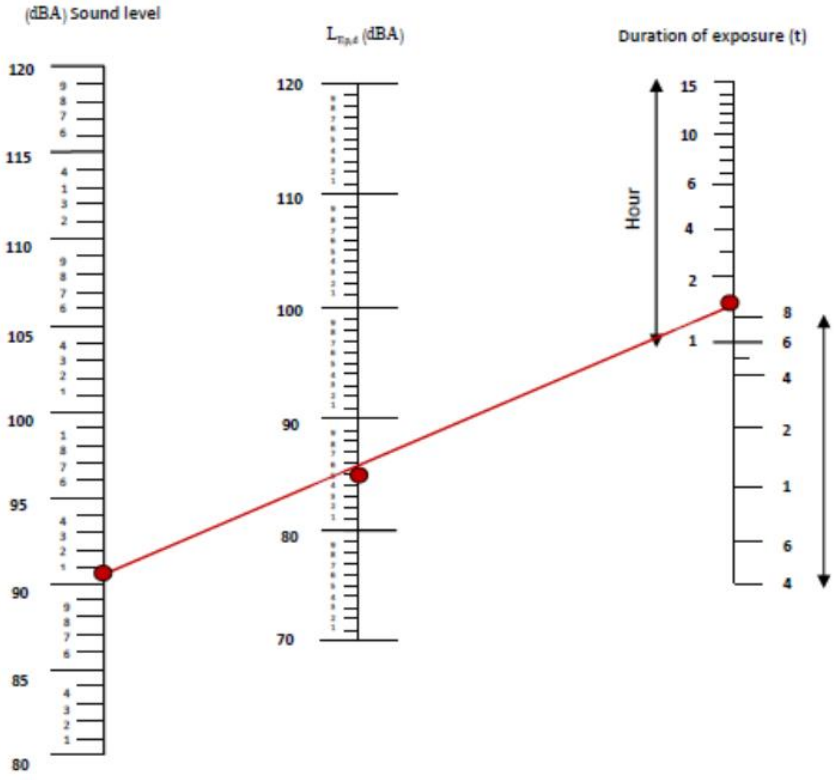

Fig. 6- Nomogram of calculating the allowable duration of exposure to sound for athletes in bodybuilding clubs in Mashhad
(Source: Research finding)

4. Discussion

As it is known, in Mashhad bodybuilding sports clubs, the athlete is exposed to high noise pollution. The results of the study showed that the voice level was higher in the sessions attended by male athletes than in female sessions. Also, in the morning sports time (10-10.30), the sound level was significantly lower than in the evening time (19- 19.30), which is probably due to the lower number of athletes in the morning, compared to the evening. This research methodologically is in line with the study conducted by Taheri et al. (2019). However, their results cannot be generalized and compared with each other, because the environment studied in this study was closed space. Nevertheless, the results are largely consistent with the results of studies by Bahmanpour et al. (2011). Bodybuilding is one of the noisy sports activities due to the use of heavy equipment and also due to the large number of athletes in a limited space.

Throwing weights, colliding weights with each other, moving equipment, playing music, talking to athletes, motivational shouts, etc. all provide the basis for raising the volume level. Accordingly, the long-term or frequent presence of an athlete in an environment with high noise levels can increase the risk of injuries due to noise pollution and may even reduce the efficiency of the athlete. Examination of the data and records of sports clubs shows that clubs with lower sound levels had one of the following:

- Do not play music or play music with slow sound;
- Having a large space and a ceiling with a height of more than 5 meters;
- Use of weights and equipment with rubber cover;
- Having flexible rubber flooring.

In general, the absence of the above conditions has caused an increase in the sound level in the studied clubs. Of course, there was no significant difference in terms of sound level in different areas of Mashhad and in this regard, there can be no difference in terms of sound level published in bodybuilding clubs based on zoning in Mashhad.

Comparison of the average sound level in the studied gymnasiums with world standards indicates a relatively large distance of the sound level in most stations with the US Environmental Protection Agency (EPA) standard for outdoor recreation and sports spaces (minimum 55 and maximum 70 decibels). Also; Compared to the standard of sports and recreational spaces and parks (England) which is equal to 55 decibels and also according to the limit set by the noise level in residential uses, by the Environmental Protection Agency (55 dB from 7 am to 10 pm), a huge difference is observed.

However, due to the permissible occupational limits and the maximum exposure time set at 2 hours, all clubs are below the threshold of the NIOSH and OSHA standards and only 2 clubs are below the ACGIH threshold (91 Decibels). The average sound level of bodybuilding clubs in Mashhad was set at 87.6 decibels, which is a high level.

Also; the estimated level of sound exposure Leq (dBA) is also equal to 90.61 dB, which indicates a higher rate. On the other hand, the individual daily dose of LEp,d of an athlete in the studied fitness clubs, was equal to 84.58 dB. As it is known, in the bodybuilding sports clubs of Mashhad, the athletes of this field are exposed to high noise pollution.

As it is known, in the bodybuilding sports clubs of Mashhad, the athletes of this field are exposed to high noise pollution. According to the nomogram pattern drawn for them, it is possible to calculate the time allowed for exposure to sound in gyms for athletes, which is equal to 1 hour and 40 minutes. Therefore; it turns out that the average time spent by athletes in this area is about 20 minutes longer than the allowable time. Finally, the following can be suggested as solutions to reduce the sound level received in sports environments such as bodybuilding:

- The maximum time of an athlete in the gym should not be more than 1 hour and 30 minutes;
- Preferably use the early hours (morning) to exercise;
- Choose sports clubs that have large halls and high ceilings, as well as walls made of foam or absorbent materials;
- The weights have a rubber protective cover and the equipment has wheels to move;
- Set the music playback volume to balanced (70 decibels);
- Athletes are prohibited from shouting, talking loudly and throwing weights;
- The gym must be furnished with flexible and durable flooring;
- For sports halls in accordance with the use and space and equipment inside it, the range capacity should be determined;
- Ventilators and air conditioners are standard and serviced regularly to avoid non-standard noise. Avoid multipurpose spaces and overlapping sports fields.

5. Conclusions

According to the standards of the World Health Organization, if an athlete is exposed to an excessive sound level above 80 decibels, the occurrence of aggressive behaviors is normal, the result of which can be seen in the clubs under study. On the other hand, hearing loss (temporary and even permanent) is another consequence. According to the IOC (2000) guidelines, because these types of sports facilities do not meet the standard requirements in terms of health and environmental safety, they are not recognized as a sustainable and green sports environment.

6. Conflict of interest

The authors declare that they have no conflict of interest.

7. Additional Information and Declarations

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Competing Interests

The author declares there is no competing interests, regarding the publication of this manuscript

Author Contributions

Ling-Hsiang Chang: Article review

Hooman Bahmanpour: Proposed the plan, conceived the experiments, analyzed the data and Corresponding Author of paper

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