Approaching to hearing health of Uruguayan academic musicians

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ABSTRACT

Within the framework of an interdisciplinary research team, a first audiometric database of Uruguayan academic musicians (singers and orchestral musicians) was developed. Before performing a pure-tone audiometry on each of the musicians, an Occupational Physician conducted an interview (an anamnesis form with about 50 questions) and an otoscopy. Hearing loss was evaluated based on two criteria: one preventive (mean loss at 2000 Hz and 4000 Hz) and the other reparative (mean loss at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz). Both values were included -one at a time- as components of a vector per participant, along with 31 other variables preselected from the anamnesis. By performing Cluster Analysis and Principal Components Analysis (PCA), each set of 32 variables was reduced to a smaller one of 10 variables. The final sets differed in 1 of the 10 variables: in the first case, the history of having the mumps mattered; while in the other case, the tenth variable was the need to increase the volume on the TV.

INTRODUCTION

Artists are a community that is not always given the same attention as other work groups, from the point of view of occupational health. For example, in Uruguay they are explicitly excluded from the state medical health coverage which corresponds to workers. Furthermore, the idea that professional musicians should not suffer hearing loss due to their profession, since “they enjoy what they do". However, in recent years these issues have gained greater prominence, by accompanying legal actions promoted by artists' groups or reviewing prior complaints.

In this context, a group of researchers from three different areas (health, arts, science & technology) from the Universidad de la República (Uruguay) proposed an interdisciplinary project to quantitatively analyze the hearing health of two groups of academic musicians. The target population was a group of orchestral musicians and a group of students and teachers from the Music School. The proposal was aimed at obtaining a Type “B” Database of Uruguayan academic musicians exposed to high sound levels in their professional performances. The Type “B” database (according to ISO 1999:2013 [1]) is a database obtained from hearing threshold measurements and not by mere theoretical calculations.

The project was carried out between March and December 2019. A statistical re-processing of its results is presented hereby.

MATERIALS AND METHODS

Audiometries, otoscopies and anamneses

The first task of the project was the design of an ad-hoc anamnesis form. Based on the usual forms of anamnesis, and considering the particularities of the population with which we would work, two working sessions of the whole research group were used to define the contents and the formulation of the questions. The basis was taken from the form proposed by the National Institute of Health and Hygiene at Work (INSHT) of Spain [2].

When we began to work with each of the art groups (the singers from the Music School and the musicians of the SODRE Symphony Orchestra), two workshops had been held to present the project. The goal of these workshops was to introduce the topic among the attendees, to explain the activities to be carried out, to let them know of the need to sign a formal consent, and to dismiss any doubts in relation to the project and the subsequent use of the information gathered.

Each participant underwent pure tone air and bone conduction audiometries. The tests were carried out by professors, including advanced students of Speech Therapy [3]. In addition, an otoscopy and anamnesis were also performed on each participant, by professors from the Occupational Health Department of the Faculty of Medicine. Participants were previously informed of the necessary precautions in the time prior to performing the audiometry: 12 hours of auditory rest (including not using personal audio devices); not having any ear infectious symptoms. In case of having undergone antibiotic treatment, please inform the Physician prior the otoscopy. They were also asked to tell Physicians if any these precautions were not met.

The logistics of the work in place had the support of the singing teachers of the Music School and of the Human Capital Management of SODRE, which organized the clinics. In each of the cases, all the tasks were carried out in the respective institutional premises, in rooms selected for privacy and low background noise. The participants were previously scheduled, in order to reduce their waiting time.

As a methodology peculiarity, special care was taken on the audiometries to reach the threshold level of perception in each of the frequency bands (instead of stopping at the audiometric zero). The professors explained this particularity to the Speech Therapy students who participated in the project, since it is not a general guideline in performing audiometries. In this case, it was mandatory because the aim of the task attempted to assess the hearing threshold level and not to verify the absence of auditory pathology [4, 5].

Main characteristics of the population

The group of 86 musicians involved in this study could be described as mentioned in Table 1. Some other variables were considered in the anamnesis, for example: number of hours of practice, use or personal protection equipment, social exposure to high sound pressure levels (e.g. discotheques, motorcycles, hunting, target practicing with fire arms), family history of hearing disabilities, exposure to carbon monoxide, measles, rubella, abortions, tumours, smoking, consuming alcoholic beverages, hypertension, diabetes, tinnitus, ear pain, traumatic brain injury, noise annoyance, perception of hearing well, need of increase the TV volume, annoyance of loud noises, etc.

Table 1: Main information about the musicians engaged in this study

	Singers		Orchestra players	
Number of participants	45		41	
Male	16	Baritones 8	27	Strings: 15
		Tenors 1		Winds: 9
		Others 7		Percussion: 3
Female	29	Sopranos 15	14	Strings: 10
		Mezzo sopranos 7		
		Contraltos 6		Winds: 4
		N/D 1		
Male Ages	Less than 35: 9		Less than 35: 14	
	35 – 55: 4		35 – 55: 10	
	More than 55: 3		More than 55: 3	
Female Ages	Less than 35: 13		Less than 35: 7	
	35 – 55: 11		35 – 55: 7	
	More than 55: 5		More than 55: 0	
Less preferred ear	Male	Right	Male	Left
	Female	Both	Female	Left
Tinnitus (only for examples exposed ≥ 20 h/week)	Male	12 (6 baritones)	Male	13 (7 strings)
	Female	11 (5 sopranos)	Female	7 (6 strings)
Irritability after exposure	Male	5	Male	14 (6 strings)
	Female	6	Female	11 (6 strings)
Occupational scotome at 4000 Hz or 6000 Hz	8 (1 out of 8 presents hearing loss ≥ 25 dB)		13 (2 out of 13 present hearing loss ≥ 25 dB)	

Average Hearing Loss (Perte Acoustique Moyenne, PAM)

The ISO 1999 Standard defines two types of audiometric databases: type A is a theoretical basis that represents the minimum hearing loss expected in people of different ages, due to aging or presbycusis; and type B is an experimental database that reflects the current hearing loss of people due to socioacusis [1].

Obtaining the database involved digitizing the audiometric records in all the frequencies bands prior to processing them. The anamneses responses were previously anonymized and digitized by the health team. However, as we gathered a rather small amount of data (86 musicians), the original goal of obtaining an experimental database of hearing loss from academic musicians in Uruguay could not be achieved with this sample. Hence, for its processing, it was necessary to combine the experimental results with some calculating procedures. It was decided to adapt the methodology proposed in [6], which is applied to determine the Acoustic Dangers in the workplaces. The first two steps are:

- Step 1. Computing the current hearing loss of each participant, by applying the preventive criterion (2000 + 4000)/2.
- Step 2. Obtaining the value of the Average Hearing Loss (Perte Acoustique Moyenne PAM, in French) from the abacus of Lafon and Duclos [3]. This PAM represents the hearing loss that a person will present / would have presented at age 35. Then, the set

of original audiometric records from people of different age, becomes the set of an equivalent population consisting of people at age 35.

The value of PAM was considered another characteristic of each participant.

Multivariate Statistics Analysis

Multivariate Analysis was used to find the most relevant variables from the anamneses forms. Two tests were used: Clustering Analysis and Principal Component Analysis PCA.

Clustering Analysis attempts to reduce a large set of variables into a smaller one by grouping data according to their similarity, which is the so-called “distance” between the vectors containing the experimental data. The metric was the Euclidean distance between vectors.

PCA is another well-known multivariate test that attempts to reduce a large set of variables into a smaller one by detecting the most representative variables from the original set. This method is based on determining the eigenvectors and eigenvalues of the database. Then, the most representative variables will be those that explain a higher percentage of data variance.

Both tests were used to synergize their results for reducing the number of variables and finding the most interesting, when working with different hearing loss assessment criteria. All the statistics were performed using free statistic software PAST3 (Paleontological Statistics Software Package for Education and Data Analysis).

The process had five steps that are detailed hereby. The figures illustrate the case of applying the criterion: hearing loss is the arithmetic mean of the losses at 1000 Hz, 2000 Hz and 4000 Hz, what is usually written as “criterion (1000 + 2000 + 4000)/3”.

- **Step 1.** At once, a Clustering Analysis is applied in order to reduce the number of variables to a maximum of 10. The red line in Figure 1 cuts exactly ten brackets.

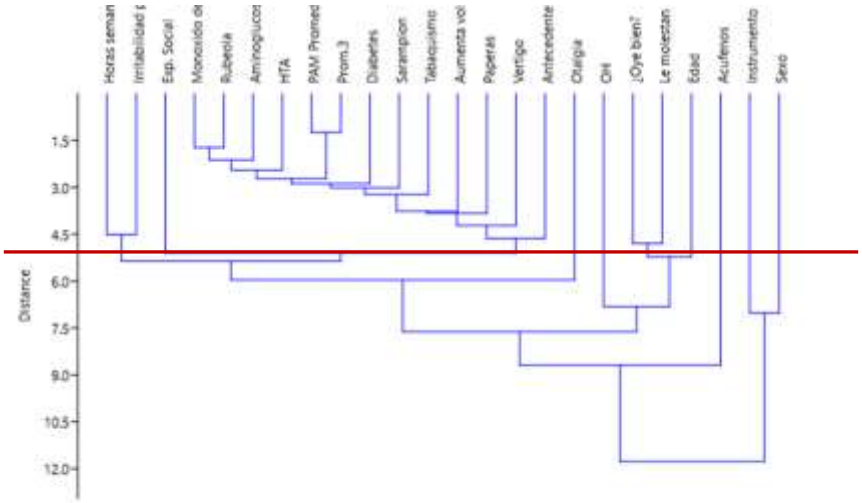

Figure 1: Dendrogram obtained at step 1

- **Step 2.** The cut brackets that have only one variable at its extreme define the first set of selected variables. In two of the three cases, they were 8 variables; in the other case, they were 7. For the case of this example, these variables were gender; music

instrument; tinnitus; age; alcohol consumption; otalgy (ear pain); social exposure to noise (noisy hobbies).

- **Step 3.** The selected variables were excluded from the dataset, and a PCA was performed to the other variables.

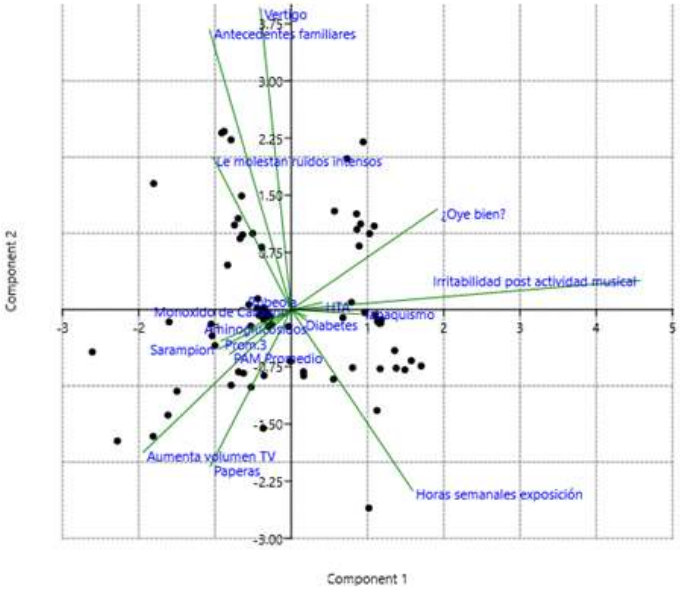

Figure 2: Scatter plot obtained at step 3

- **Step 4.** The first important change of slope in the percentages of variance related to each component diagram indicates the number of components to consider. In this case is only the first (Figure 3).

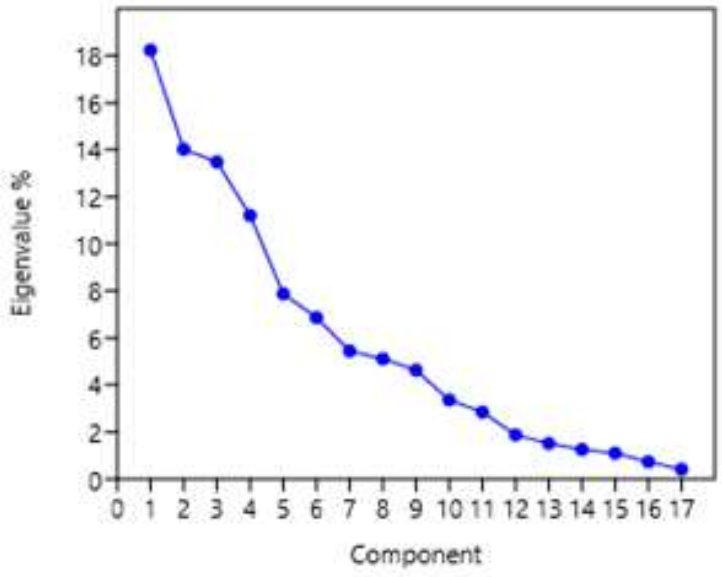

Figure 3: Percentage of variance related to each component

- **Step 5.** The variables more significant from the first component from the ACP were included in the selected set of the most important ones. In the example, irritability after exposure explains 74.4 % of PC1 variance. This variable is excluded from the dataset and the process loops to Step 3 until a set of 10 excluded variables would be achieved.

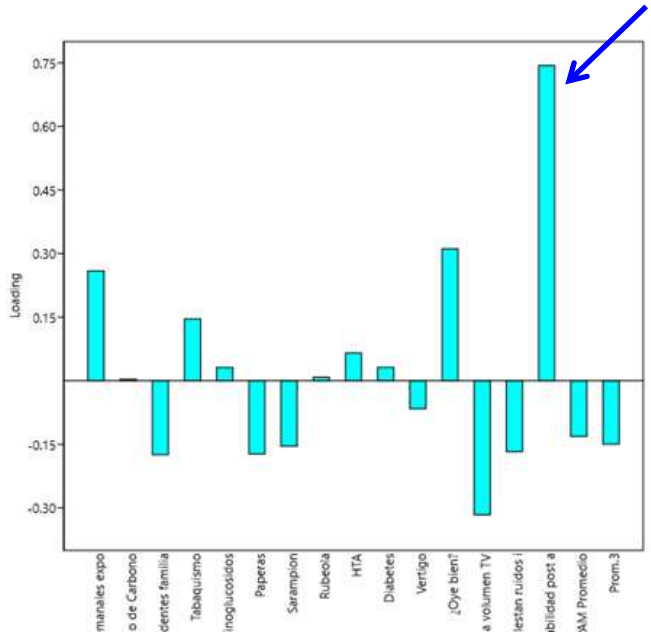

Figure 4: Loads diagram of PC1

In this example, the final set of main variables was composed by: gender; music instrument; tinnitus; age; alcohol consumption; otalgy (ear pain); social exposure to noise (noisy hobbies); irritability after exposure; family history of hearing illness; need of turning up the volume of TV.

RESULTS

The explained process was conducted considering three different hearing loss assessment criteria.

The set of 10 main variables obtained in each case is detailed in Table 2.

They are sorted as to better highlight the few differences between them.

Table 2: Main variables for different hearing loss assessment criteria

Preventive Criterion (2000+4000)/2	**Criterion (1000+2000+4000)/3**	**Reparative Criterion (500+1000+2000+4000)/4**
gender	gender	gender
tinnitus	tinnitus	tinnitus
alcoholic beverages consumption	alcoholic beverages consumption	alcoholic beverages consumption
otalgy (ear pain)	otalgy (ear pain)	otalgy (ear pain)
family history of hearing illness	family history of hearing illness	family history of hearing illness
irritability after exposure	irritability after exposure	irritability after exposure
social exposure to noise (noisy hobbies)	social exposure to noise (noisy hobbies)	social exposure to noise (noisy hobbies)
music instrument	music instrument	music instrument
vertigo	age	vertigo
mumps	need of turning up the volume of TV	need of turning up the volume of TV

DISCUSSION

The set of main variables presented at Table 2 for the three different hearing loss assessment criteria have more similarities than differences. Thus, their differences are worth mentioning.

The preventive criterion is the only one that does not include the need of increasing the TV volume, but also the only one for which having the mumps matters. It shares “vertigo” with the reparative criterion as an important background.

Vertigo does not appear in the list of main variables of the second case. This case is the only one for which age is a representative variable.

FINAL REMARKS

A set of 86 academic musicians took part of an interdisciplinary diagnosis of their hearing health. The number of male and female was the same (43).

An audiometry, an otoscopy and an anamnesis were performed on each of the participants. A specialized health team carried out all of the tests.

The data were processed with free statistics software PAST3, which allows to perform usual univariate and multivariate tests.

A particular sequence of using Cluster Analysis and Principal Components Analysis allowed to reduce a set of more than 30 variables to only 10. This sequence was performed three times, including results of three different hearing loss assessment criteria, one at a time.

The three sets of 10 main variables were not the same for the three assessment criteria; however they had more elements in common than differences.

The preventive criterion (2000+4000)/2 is the only one for which the history of having the mumps mattered.

When the relative weight of the loss at 4000 Hz decreases, current manifestations of hearing loss (as the need to increase the TV volume) became more important.

The link between vertigo and hearing loss seems to be an interesting topic to further research.

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