IOSR Journal of Nursing and Health Science (IOSR-JNHS)
e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 11, Issue 1 Ser. VI (Jan. – Feb. 2022), PP 09-14
www.iosrjournals.org

Evaluation of the impact of the practice of wind instruments on musicians respiratory function

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Abstract
Introduction: *For the practice of a wind instrument, respiratory control is the technical skill with the greatest impact on sound production. The growing number of published articles reflects the lack of consensus about this theme. Hence the pertinence of this study, whose general goal is to assess the impact of the practice of a wind instrument on the respiratory function of musicians.*
Methodology: *A formulary was used to data collection. Were performed 51 forced spirometries to non-smokers musicians, older than 18 years and without diagnosed respiratory pathologies. Subsequently, 23 individuals performed the whole-body plethysmography and the study of maximum expiratory pressures. The impact of the practice of wind instruments on the respiratory function of wind instruments players, of several instruments family (brass or wood), in relation to the years of musical practice and regularity of performance of the instrument (amateurs or professional musicians) was assessed. The spirometric values were also compared with the ECCS equations and the Quanjer equations. Statistical analysis was executed with the IBM SPSS statistical software (version 22).*
Results: *The spirometric results (FVC, FEV1/FVC ratio and FEV1) were lower when the Quanjer equations were used as reference. There was no statistically significant differences in spirometry, between amateurs and professionals, the same happened when we compared the spirometry results considering the wind instruments family. The years of wind instrument practice appear to have a negative impact on respiratory function. As for respiratory muscles, the measured MEP values were significantly higher in musicians practicing brass instruments. In the evaluation of the non-mobilized volumes, there were no statistical significant differences between the RV%, TLC% and RV/TLC% parameters obtained between brass and wood instruments, as well as the years of musical practice and the regularity of execution.*
Discussion/Conclusion: *The practice of wind instruments doesn't seem to have a negative impact on the respiratory function of the studied musicians. The use of the 5th percentile, obtained through Quanjer equations, is free of bias due to age, height, gender and ethnic groups, are variables considered in the formula of the Quanjer equation and should be applied in detriment of the 70% cut-off referred by GOLD, which can overdiagnose older individuals and generate many false positives in a larger population. The years of musical practice appear to have a negative impact on expiratory flow rates, yet the years of practice do not reflect the periodicity which the musician play the wind instrument, which means that this result maybe the consequence of another factor. The maximum expiratory pressures were higher in the brass players, possibly due to the training that is necessary to perform these instruments, which have a high resistance. Although the article in question contributes to the lack of consensus in the literature, further studies involving other LFTs and other parameters related to the practice of wind instruments are necessary.*
Keywords: *Wind instrument players, spirometry, whole-body plethysmography, respiratory muscle testing, respiratory control, professional wind instrument players.*

Date of Submission: 16-02-2022 Date of Acceptance: 02-03-2022

I. Introduction

Good practices in the use of a musical instrument require of its performer a broad set of qualities and technical skills. For the wind instrument players, among the qualities and technical skills required, the most important is the breath control, since it is used to produce the sound when the air column is present in each instrument[1–6]. This control exerts an important action on the breathing pattern developed by the musician, which consists of a short and deep inspiration followed by a prolonged expiration, which is not only dependent on the pressure and airflow required by the instrument, but also depends on the need for lung ventilation[6,7].

That way, some investigators assume that the wind instrument players have exceptional respiratory functions[2,7–9]. However, there is still no consensus in the literature about this theme, hence the pertinence of this study, whose general goal is to assess the impact of the practice of a wind instrument on the respiratory function of musicians, through a set of lung function tests (spirometry, whole-body plethysmography and maximum expiratory pressure), to evaluate the effects of the resistance produced during the sound emission by wind instrument players.

The specific objectives are to evaluate the impact of the practice of wind instruments on the respiratory function of musicians according to the different families of instruments (wood or brass) and to verify their relationship with the years of musical practice and regularity of instrument performance (professional or amateur musicians). We also compared the values of the spirometric parameters with reference to the ECCS[10] equations and the Quanjer equations of the Global Lung Function Initiative (GLI 2012)[11].

II. Methodology

Based on the accessible population, formed by wind instruments players from two philharmonic bands, a convenience sample was obtained, consisting of 51 musicians who agreed to be part of this descriptive-correlational cross sectional study. All participants met the following criteria: non-smokers musicians, older than 18 years and without diagnosed respiratory pathologies.

An Ethical Conduct was followed by maintaining the confidentiality and anonymity of both the study participants and the data collected, and a written consent was obtained from them.

Before the lung function tests (LFT), anthropometric data were collected and a form was applied to obtain the following variables: professional activities, housing characteristics, daily medication, clinical history and musical practice.

The study of respiratory function started with the performance of forced spirometry in the study participants. The forced spirometry was performed with a portable turbine spirometer (CareFusion, MicroLab). The following parameters were measured: FVC, FEV1, FEV1/FVC% ratio, PEF, FEF25-75%, FEF25%, FEF50% and FEF75%[12]. For each participant three acceptable and two repeatable flow-volume curves were selected[12,13].

To all musicians that were available (n=23), after the forced spirometry, a whole--body plethysmography was performed on a plethysmograph of constant volume and variable pressure (Jaeger, MasterScreen Body). The following parameters were measured: RV, TLC and RV/TLC% ratio[14]. These participants also measured maximum expiratory pressure (MEP), and the peak expiratory value was recorded[15].

The equipment was calibrated before the tests were performed. The LFT were performed following the most recent guidelines from the American Thoracic Society and the European Respiratory Society (ATS/ERS)[13–16], and the results of the tests were evaluated according to the fixed percentages proposed by the Global Initiative for Chronic Obstrutive Lung Disease (GOLD)[17] and ATS/ERS and compared to the Quanjer equations of the Global Lung Function Initiative (GLI 2012)[11].

Statistical analyses were performed using the statistical software IBM Statistical Package for the Social Sciences (SPSS - version 22). A value of $p<0,05$ was considered statistically significant. Descriptive statistics were indicated as mean ± standard deviation. Student T-test, Mann-Whitney and the Spearman correlation test were applied according to the sample distribution.

III. Results

The study sample included 17 women (33%) and 34 men (67%) with mean age of 29,35 ± 8,31 years (range: 18-56 years), mean weight of 73 ± 15 Kg, mean index body mass (IBM) of 25,4 ± 3,8 and mean height of 169 ± 10 cm.

Of the 51 musicians, with an average of 15,1 ± 9,8 years of musical practice (range 2 - 48), 14 were professional wind instrument players with an average of 17,0 ± 9,1 years of musical practice, the remaining were amateur instrument players with an average of 14,3 ± 9,8 years of musical practice. Most of the musicians (24 men and 3 women) played brass instruments (53%), the remaining (10 men and 14 women) played wood instruments (47%).

As already mentioned initially, and in the methodology, we compared the values of the spirometric parameters measured with the reference values of the ECCS[10] (%measured/predicted values). The results were evaluated by the limits of normality (cut-offs) proposed by the GOLD[17] and ATS/ERS[13] (FVC and FEV_1 80% according to ATS/ERS[13] criteria and *Direção Geral de Saúde*[12], 70% for the FEV_1/FVC ratio according to GOLD[17] criteria, and 65% for FEF25%, FEF50%, FEF75% and FEF25-75%[18]). We have classified all spirometry as “without ventilatory changes”.

We obtained mean values of FEV1% = (102,804 ± 11,521), FVC% = (104,431 ± 12,256), PEF% = (104,216 ± 15,927) e FEF25% = (101,240 ± 18,901), FEF50% = (92,020 ± 20,717), FEF75% = (82,650 ± 25,831) e FEF25-75% = (87,290 ± 20,125) e FEV1/FVC% = (83,940 ± 5,308) (**Table 1**).

We compared the values of the absolute measured spirometric parameters with the ECCS[10] reference values, in liters, obtaining the median values of FEV1 = 0,09L, FVC = 0,11L e PEF = 0,35L.
In the comparison between the predicted values by the ECCS[10] equations and those calculated from the Quanjer equations (GLI 2012)[11] for FVC, FEV_1 and FEV_1/FVC, we verified that there are significant differences.

Table 1: Spirometry results based on ECCS equations

Spirometric Parameters	n	Mean	Standard Deviation
FEV1 (L) -%Pr	51	102,804	11,521
FVC (L) -%Pr	51	104,431	12,256
PEF (l/sec) -%Pr	51	104,216	15,927
FEF25 (l/sec) -%Pr	51	101,240	18,901
FEF50 (l/sec) -%Pr	51	92,020	20,717
FEF75 (l/sec) -%Pr	51	82,650	25,831
FEF25/75 (l/sec) -%Pr	51	87,290	20,125
FEV1/FVC%	51	83,940	5,308

* significance level of 0,05

FEV1 - forced expiratory volume in the first second; FVC - forced vital capacity; PEF - peak expiratory flow; FEF25% - forced expiratory flow at 25% of the FVC; FEF50% - forced expiratory flow at 50% of the FVC; FEF75% - forced expiratory flow at 75% of the FVC; FEF25/75% - mean forced expiratory flow between 25 and 75% of the FVC; FEV1/FVC% - proportion of the vital capacity exhaled in the first second

On average, the values predicted by the recent guidelines (GLI 2012) in all of the above parameters are lower than the values obtained by the ECCS equations (**Table 2**).

Table 2: Comparison between the ECCS reference equations and the Quanjer equations (GLI 2012)

Parameters	n	Mean	Standard Deviation	t	df	p	Correlation Coefficient
FVC (L) - ECCS	51	4,416	0,849	34,970	50	0,000*	0,993
FVC (L) - GLI	51	3,733	0,749				
FEV1/FVC% - ECCS	51	82,330	1,894	65,724	50	0,000*	0,913
FEV1/FVC - GLI	51	72,902	2,402				
FEV1 (L) - ECCS	51	3,740	0,688	36,665	50	0,000*	0,991
FEV1 (L) - GLI	51	3,123	0,604				

* significance level of 0,05

Concerning the wind instrument family, there were no statistically significant differences in the spirometric parameters of the musicians practicing instruments of wood or brass, however, the brass instrument players showed higher values, except for FEV_1/FVC% and FEF75%. The practice of wind instruments over the years seems to have a negative impact on the values of the spirometric parameters: FEV_1/FVC%, FEF50%, FEF75% and FEF25-75%. There were no statistically significant differences in the spirometric parameters between amateurs and professionals, although in the last group the values of the spirometric parameters were increased.

In the study of maximal expiratory pressures, the MEP value was significantly higher in musicians practicing brass instruments. Although, professional musicians had higher mean MEP values compared to amateur musicians, they weren't statistically significant (**Table 3**).

Table 3: Comparison of the MEP value obtained according to the wind instrument family and the type of instrument player

Parameters			n	Mean	Standard Deviation	t	df	p
MEP ($cm\ H_2O$)	Wind Instrument Family	Wood	13	10,8254	2,99292	-2,295	21	0,032*
		Brass	10	13,771	3,12691			
	Type of Instrument Player	Amateur	15	11,2267	3,24512	-1,821	21	0,083*
		Profissional	8	13,755	3,01774			

* significance level of 0,05

MEP - maximal expiratory pressure

Analysis of the results showed that the years of practice of the wind instrument didn't had any impact on the expiratory muscle strength of the musicians who participated in the study.
In the statistical analysis of the non-mobilized volumes, no statistically significant differences were found between the measured RV%, TLC% and RV/TLC% parameters, among wood and brass instrument players, as well as in professional and amateur musicians. Likewise there is no significant correlation between the values of the non-mobilized volumes and the number of years of musical practice.

IV. Discussion

The values of the spirometric parameters of the musicians that participated in the study were all unchanged, when evaluated through the cut-offs proposed by GOLD[17] and ATS/ERS[13], which indicates that the practice of wind instruments doesn't cause changes in the respiratory function, as Kock concluded by stating that the practice of wind instruments has no negative impact on the respiratory function of the musicians[19]. Deniz concluded exactly the opposite[4]. It has been common practice to evaluate the results of spirometry using cut-offs as the lower limit of normality (LLN), however, have emerged studies that conclude that the application of such values may lead to errors in interpretation[20].

In the comparison between the predicted values by the ECCS equations and those calculated from the Quanjer equations (5th percentile), we concluded that the mean values of the spirometric parameters were lower when the Quanjer equations were used. This may result from the fact that the use of the 5th percentile to define the LLN is dependent on a set of variables (height, gender, ethnic groups) that vary from individual to individual, especially the age[12,21].

Concerning the family of wind instruments, there were no significant differences in the spirometric values evaluated between brass and wood musicians, although the first ones presented higher values, while not significantly, except for FEV_1/FVC% and FEF75%. The study by Deniz obtained the same conclusions[4]. Playing a wind instrument requires a breathing control by the musician, which is dependent on the pressure and airflow required by the instrument. Thus, respiratory training is also dependent on the instrument family, which may explain the differences found[4].

The results of some studies show that short periods of musical practice may promote significant statistical increases in most dynamic spirometric parameters (FVC, FEV_1)[21], such as those presented by Zuskin. That states that a greater number of years of practice is correlated with higher values of FEV_1[22]. This increase in dynamic volumes may be justified by the breathing pattern adopted by the musicians when they undergo a deep inspiration followed by a prolonged expiration[1,3]. In contrast, other studies indicate that there are parameters that correlate negatively with the years of practice, such as FVC[4,21] (weak negative correlation between total rehearsal time and FVC, that is, the longer is the reported rehearsal time, the lower is the value found for FVC)[19].

In our study there were no statistically significant differences between the spirometric parameters analyzed, since it only seems to exist a negative impact on the respiratory function (mainly decrease in expiratory flow rates) as the years of practice increase. Similar results, decreased expiratory flow rates in the study population compared to the control group[4], are report by Deniz. It has been related that respiratory diseases can severely harm the wind instrument players, with bronchial asthma being one of the most common chronic lung diseases among these musicians. Besides that, increased airway reactivity may be a justification for the finding data. Other studies indicate that the breathing of large volumes of air facilitates the onset of cancer in the pulmonary epithelium[4,23]. On the other hand, the fact that an instrument player affirms that he has practiced an instrument for some years, does not reflect the periodicity of the practice.

Although there were no statistically significant differences between professionals and amateurs musicians, the professionals had higher spirometric values. This finding could occur due to the increase in FVC in professional musicians, but that wasn't verified in our study. Ksinopoulou concluded that a professional involvement in the practice of wind instruments presents benefits in the respiratory function[24]. Besides that, significantly higher PEF values have been found in musicians that practice regularly, when compared with amateurs or non-musicians[1]. The possible explanations for ours results are that the musicians who participated in the study were young and the group of professional, even though they were, did not practice the wind instrument as regularly as expected[22]. The presence of slightly higher PEF could be expected, but this was not found, contrarily to the findings of Hahnengress[7]. However, half of the individuals evaluated in our study showed an increase of 350 ml in the measured PEF value relatively to that predicted according to ECCS[10].

The maximum expiratory pressures found were significantly higher in the brass instrument players comparatively with the wood instrument players. These findings may be due to the fact that the brass instrument players perform exercises against the high resistance of the instrument, especially with the expiratory muscles[5], occurring in these musicians greater differences in the thorax pressure, faster and more frequent, so that the mechanical stretching of the muscles is superior[7]. Fiz concluded that the trumpet players had increased pressures and that this was related with the years of practice, a relationship that we couldn't corroborate[5].

There have been few published studies that evaluate the impact of wind instruments practice on the respiratory function relatively to the non-mobilized volumes. In our study, the TLC%, RV% and RV/TLC% values were similar between brass and wood instrument players, these results were also found by Fuhrmann, who states that there is no consistent evidence that the practice of wind instruments changes the lung volumes, being reasonable to presume that the ability to sustain long musical phrases is due to learning to control airflow and not necessarily due to better respiratory functions[8].

This study presents some limitations in relation to the demographic differentiation of the sample, being carried out exams mainly to a young population, with few years of musical practice and subsequent chronic alterations due to them. More studies will have to be realized in the future, involving a greater number of professional wind musicians, since that number in our study was reduced and, with regular practice. The years of practice should be replaced by the frequency and duration of the weekly sessions dedicated to the wind instrument, since the number of years of musical practice doesn't reflect the periodicity of the practice of the wind instrument.

The discussion of our results of the whole-body plethysmography was limited by the reduced number of published articles contemplating the evaluation of the non-mobilized volumes.

The results of this study didn't show improvement of the respiratory function with the regular practice of the wind instruments. A way to assess the benefit of practicing a wind instrument is to adapt a plan with the practice of the wind instrument in individuals that already have a pathology and evaluate frequently and with recourse to the LFT the in(existence) of changes in the respiratory function after practice.

V. Final considerations

Having an excellent breathing control is essential for the wind musicians, considering that is how they produce sound by moving the column of air present in each instrument[6,7].

The results obtained in this study refute the possibility that the practice of wind instruments has a negative impact on musicians' respiratory function, as some studies suggest. However, the years of musical practice appear to have a negative impact on the expiratory flow rates. Yet the years of practice don't reflect the periodicity with which the musician practices the wind instrument, which means that this result can be a consequence of another factor.

The use of the 5th percentile, obtained through the Quanjer equations is free of bias due to age, height, genre and ethnic groups be variables considered in the equation formula. This one should be applied in detriment of the 70% cut-off referred by GOLD, which can overdiagnose older individuals and underdiagnose younger individuals, resulting in many false-positives and false-negatives, respectively, in a larger population[25,26].

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