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ORIGINAL ARTICLE

Analysis of the breathing function in wind instrumental musicians

Análise da função respiratória em músicos instrumentistas de sopro

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KEYWORDS
Music
Pulmonary ventilation
Respiratory function test
Wind instrument

ABSTRACT

Objective: To conduct an integrative review of lung function and respiratory muscle strength in wind instrument musicians. The relationship between respiratory function and the use of wind musical instruments is an area of knowledge that has not been extensively explored.
Methods: A bibliographic review was carried out in the MEDLINE, Embase, Cochrane, PeDro, BVS, Scopus, Web of Science, and SciELO databases by combining the keywords "respiratory function test", "wind instrument", musician, "pulmonary ventilation" and "Lung Function Test".
Results: Initially, 108 articles were found, of which 11 were selected, totaling 596 wind instrumentalists who were part of the study groups. In most studies, musicians showed lower values of expired volume in one second (FEV1) and forced vital capacity (FVC) in spirometry than in the control group. However, there was no difference regarding the FEV1/FVC ratio, just as there was no difference in respiratory muscle strength or relationship with respiratory diseases.
Conclusion: Current studies regarding the effect of wind instruments on individuals are unable to show positive or negative impacts on the respiratory health of this population.

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PALAVRAS-CHAVE

Instrumento de sopro
Música
Teste de função respiratória
Ventilação pulmonar

RESUMO

Objetivo: realizar uma revisão integrativa a respeito da função pulmonar e da força muscular respiratória nos músicos de instrumentos de sopro. A relação da função respiratória com a utilização de instrumentos musicais de sopro é uma área do conhecimento ainda pouco explorada.
Métodos: Realizada a revisão bibliográfica nas bases de dados MEDLINE, Embase, Cochrane, PeDro, BVS, Scopus, Web of Science e SciELO, através da combinação das palavras-chave "respiratory function test", "wind instrument", musician, "pulmonary ventilation" e "Lung Function Test".
Resultados: Inicialmente foram encontrados 108 artigos, sendo que destes foram selecionados 11, totalizando 596 músicos instrumentistas de sopro, que fizeram parte dos grupos de estudo. Na maioria dos estudos os músicos apresentaram valores menores do volume expirado no primeiro segundo (VEF1) e da capacidade vital forçada (CVF) na espirometria que o grupo controle. No entanto, sem diferença quanto a relação VEF1/CVF. Assim como não há diferença na força muscular respiratória ou relação com doenças respiratórias.
Conclusão: Os estudos atuais a respeito da consequência do instrumento de sopro em indivíduos não são capazes de evidenciar impactos positivos ou negativos na saúde respiratória desta população.

INTRODUCTION

Wind instrumentalists can suffer from respiratory muscle overload because they are subject to excessive respiratory efforts that can occur daily for years, as in the case of professional musicians[1].

Wind instruments are all musical instruments in which the vibration of an air mass produces the sound originated by the musician[2], and are commonly divided into two large groups: "wood" and "metal". Brass instruments have a mouthpiece embouchure, and the primary means of obtaining several notes in these instruments is by varying the position of the mouth and air pressure. The sound is then generated by the direct vibration of the instrumentalist's lips over a mouthpiece. Some instruments of this group include the trumpet, trombone, and tuba. Woods, with a simple embouchure (edge), whistle (bevel), or reeds, have a certain number of lateral holes that allow them to obtain several fundamental sounds[3].

To play a wind instrument well, the instrumentalist controls several elements of the player-instrument system, starting with the source of pressurized air in the lungs and being aware of the importance of breathing and possessing qualities and technical skills in performance. Muscle activity required to maintain constant air pressure depends on lung capacity. This is because the elastic forces developed by the lungs and rib cage raise or lower the pressure within the lungs, depending on whether the lung volume is greater or less than the Functional Capacity Residual[4].

Pulmonary function can be assessed through spirometry, which measures in millimeters the volume of air that the subject can exhale from the lungs after maximum inspiration reaches total lung capacity. This vital capacity (VC) measurement can be performed during slow expiration or forced expiratory maneuvers. Spirometry is a test that allows the diagnosis and quantification of ventilatory disorders, thus helping to prevent respiratory problems[5].

The objective of this study was to conduct an integrative review of pulmonary function in wind instrument players and to analyze the characteristics of lung function and respiratory muscle strength in wind instrument musicians. We developed the following guiding question: "Do wind instrumentalists present with a more developed lung function than do non-instrumentalists in breath?"

The justification for carrying out this study is to generate knowledge in an area that is still little explored, seeking to elucidate the relationship between respiratory function and the use of wind musical instruments.

METHODS

Bibliographical research was conducted on the respiratory function of wind instrumentalists between September and December 2021 in the MEDLINE, Embase, Cochrane Library, PeDro, BVS, Scopus, Web of Science, and SciELO databases. The research used the combination of keywords "respiratory function test", "wind instrument", musician, "pulmonary function test" and "lung function ventilation test". No publication period was established as an inclusion or exclusion criterion. In May 2023, a new search was conducted in the databases to verify the occurrence of recent articles, although none was identified.

The search strategy used was: ("Respiratory Function Tests" OR "Tests, Pulmonary Function" OR "Lung Function Test" OR "Pulmonary ventilation" OR "Lung Function Tests") AND ("wind instrument" OR "wind instrumentalist" OR Musician). This strategy was adapted to match each database (Table 1).

The articles found were added to the RAYYAN online application to exclude duplicates, and then the titles and abstracts were read, with subsequent reading of the selected papers in full. Two independent reviewers selected articles by title and abstract, following the inclusion and exclusion criteria. In the case of discrepancies, a third independent reviewer analyzed for the final result. Furthermore, studies that used wind instruments as a form of respiratory therapy were excluded because our study aimed to assess the impact of using wind instruments only on instrumentalists and not on people with previous lung disease.

Variables of interest and data analysis

The study's variables of interest were related to the musicians' lung function assessed by spirometry: Forced Expiratory Volume in the first second (FEV1), Forced Vital Capacity (FVC), FEV1/FVC ratio, maximum peak expiratory flow reached in forced expiration (*peak Flow*) and inspiratory and expiratory respiratory muscle strength, respectively (maximum PI and PE). In addition, the age of the musicians, the time spent practicing instrumental music, and the correlation with any disease associated with the activity were observed. The following data were extracted: author, year of publication, sample characteristics, possible complications, and benefits of regular practice with wind instruments.

RESULTS

A total of 108 articles were found, of which 34 duplicates were excluded, totaling 74. These were analyzed in terms of titles and abstracts, of which 32 papers were selected because they met the inclusion criteria. During the screening, 2 articles were excluded because of the impossibility of accessing the full article (we contacted the authors of the respective articles but did not receive a response). After obtaining and reading the texts of the remaining 30 articles in full, 11 articles were selected. The search results are shown in Figure 1. Table 2 shows the selected articles based on each searched database.

Table 3 presents information related to publications, including the main author, objective, year of publication, journal, country, and sample of selected studies. Table 4 summarizes the included studies, including objectives, samples, and results. The eleven studies included 596 wind instrumentalists, who were part of the study groups with a mean age of 30. The reported time in the profession was an average of 2 to 10 years, with a regular practice of 5 h a week.

Table 1 — Example of strategies in search at base MEDLINE It is VHL.

Basis of data	Strategy used
Medline	#1 "Respiratory Function Tests"[Mesh] OR "Tests, Pulmonary Function" OR"Lung Function Test" OR "Pulmonary ventilation" OR "Lung Function Tests" #2 "wind instrument" OR "wind instrumentalist" OR Musician #3 (#1) AND (#2)
BVS	(MH: "Respiratory Function Tests" OR (lung function test) OR (function test, lung) OR (function test, pulmonary) OR (lung function test) OR (pulmonary function test) OR (respiratory function test) OR (respiratory function tests) OR(respiratory test) OR (ventilation test)) AND ((wind AND instrument) OR (wind instrumentalist) OR musician).

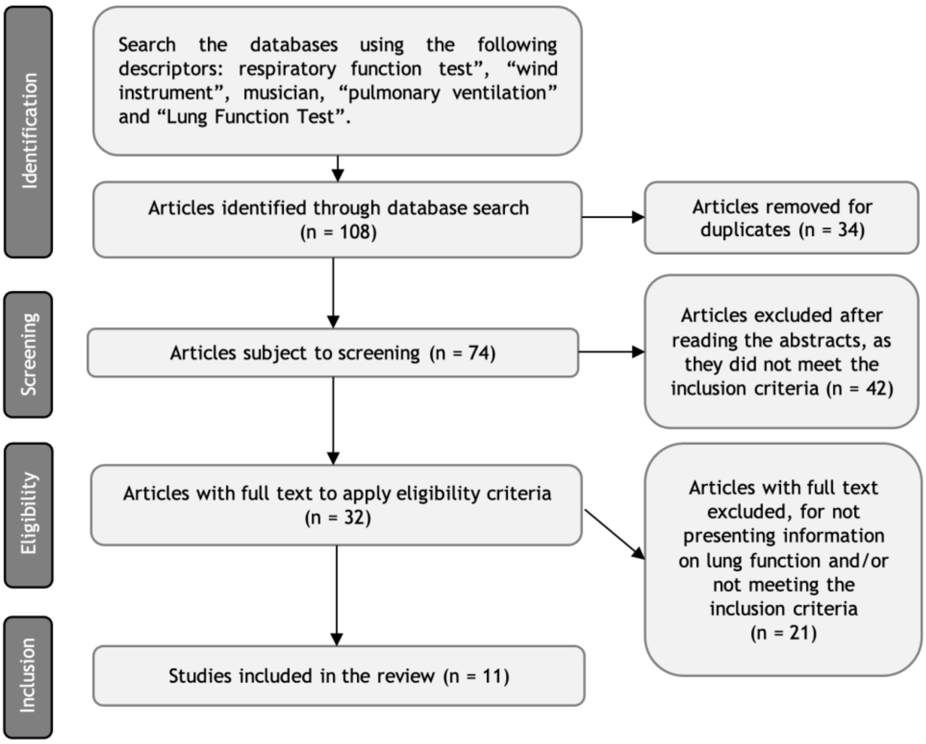

Figure 1 **-** Flowchart from the search in literature.

Table 2 — Articles found separated in agreement with each base of data researched.

Base in data	Articles found	Articles used
BVS	21	2 (18%)
Embase	20	5 (46%)
MEDLINE	30	4 (36%)
Cochrane	3	0 (0%)
Total	**74**	**11**

Table 3 — Summary of information regarding the selected publications.

Reference	Year	Journal	Country
Khuje & Hulke[7]	2012	Res J Pharm Biol Chem Sci	India
Studer et al.[12]	2019	Plos One	Australia
Brzęk et al.[14]	2016	Med Pr	UK
Granell et al.[15]	2010	Aten Primaria	Spain
Subramanian et al.[11]	2018	Indian J Physiol Pharmacol	India
Soria et al.[16]	2020	Invest Clin	Spain
Fuhrmann et al.[1]	2011	Respir Med	Australia
Deniz et al.[10]	2005	Arch Med Res	Turkey
Hahnengress & Bönng[13]	2010	Eur J Appl Physiol	Germany
Smith et al.[6]	1999	J Appl Physiol	Canada
Schorr-Lesnick et al.[17]	1985	Chest	USA

Most studies used spirometry as an evaluative tool to compare the case group (wind instrument players) and the control group (non-wind instrument players). Only the study by Smith et al.[6] did not show spirometry values in his text. Figure 2 shows three variables of interest in studies related to the pulmonary function of musicians, as assessed by spirometry FEV1, FVC, and FEV1/FVC. Of the 11 studies, 10 addressed such variables.

Three studies showed that wind instrument players have superior lung function, but most articles showed that, when compared, groups of wind instrument players had lower FVC and FEV1 values in spirometry. The VFE1/FVC ratio did not show significant differences between the groups.

DISCUSSION

Wind instrumentalists should have adequate respiratory muscle strength and preserved lung function to generate lung volumes and capacities, thus producing the appropriate musical sound on the instrument[4].

This study aimed to analyze the main findings in the literature on the lung function of musicians who play wind instruments and whether there is any change in lung function parameters between wind instrumentalists and non-musicians. The main findings of our study were: 1) Wind instrument players do not have better lung function than the control group; 2) The type of instrument played and the level of experience with the instrument are not associated with the prevalence of respiratory diseases among musicians.

Of the 11 articles found, only three showed better spirometry values in the group of musicians[7,13,14]. These gains are associated with the fact that wind musicians undergo continuous ventilatory muscle training, as voluntary training in breathing control is essential to play this type of instrument, as stated by Khuje and Hulke (2012)[7].

Only seven articles were included in a review of previous literature by Antoniadou et al. (2012)[8] on lung function in wind instrument players. They demonstrated conflicting results regarding the impact of professional wind instruments on respiratory function and their association with respiratory symptoms and chronic diseases. Our study presented four more articles than the study mentioned above. In addition, we compared the lung function of wind instrument players between the articles studied using spirometry. Our results demonstrated that most studies reported that groups of wind instrument players had lower FVC and FEV1 values in spirometry.

A hypothesis defended by Fuhrmann (2011)[1], which justifies these lower values in some studies in musicians, is that repeated deep inhalations and an increase in pulmonary pressure can damage the alveoli and small airways. However, other studies found no difference in the values of breath tests between the case and control groups. Another hypothesis is the high probability of pathogenic microbes residing in wind instruments, which could irritate the airways. However, the articles in this review did not address this aspect, thus making it impossible to prove the hypothesis raised by Marshall and Levy (2011)[9].

Among the articles studied, only 3 compared the subclasses of instruments, brass and wood. According to Fuhrmann (2011)[1] and Deniz et al. (2006)[10], there is no significant difference in lung function between woodwind and brass musicians. Only Khuje and Hulke (2012)[7] reported that clarinetists (instruments from the woodwind subclass) had higher lung functions than trumpeters (instruments from the brass subclass). However, it has not been demonstrated whether these higher values were significant.

Two studies reported that wind instrument players did not have better lung function than non-players. Subramanian et al. (2018)[11] evaluated the lung function of wind instrument players without separating between brass and woodwind instruments, demonstrating that both did not have better lung function than controls. Studer et al. (2019)[12] evaluated only players from the brass family and stated that, although lung function was similar between players and the control group, individuals with more years of practice had lower FVC values, but such values remained within normal limits. Both studies demonstrated that the lung function of wind instrumentalists is not better than that of the control group. Still, they did not exclude smokers from their research, nor did they match their sample by age, and the gender distribution was different.

Table 4 — Characteristics of the studies that examined the pulmonary function in wind instrumentalist musicians.

Study	Objectives	Sample	Results	Medium values
Fuhrmann et al.[1]	To investigate lung function in musicians, comparing wind musicians with non-wind musicians or non-musicians. Determine the lung function of musicians, depending on the instrument.	N = 102 (55 musicians and 47 control subjects).	Spirometry and static lung volume measurements were similar between participants, except for the residual volume/total lung capacity (RV/TLC) ratio, which was significantly decreased among musicians. There were no significant differences between the spirometry of the control and test groups. There were no significant differences between metal and wood subgroups.	Spirometry Group Case: FVC - 0.06 ± 0.9 FEV1 - 0.01 ± 1.0 FEV1/FVC - 0.08 ± 0.9 Group control: FVC - 0.06 ± 1.2 FEV1 - 0.07 ± 1.1 FEV1/FVC - 0.00 ± 0.8 PEmax and PImax values
Smith et al.[6]	To determine whether professional wind instrument players differed from controls in their ability to perceive respiratory pressures and lung volumes.	N = 26, 13 professional wind instrument players and 13 age-matched controls.	There was no difference in inspiratory capacity or MIP. Professional wind instrument players seem to have some inherent or acquired differences in respiratory perception and ventilatory neuromuscular control compared to normal individuals.	It does not present spirometry data in its text.
Khuje & Hulke[7]	Investigate the effect of playing a particular wind instrument. Compare the lung function of clarinet players with that of trumpet players.	N = 114 Participants were divided into 2 groups: A (56 clarinetists) and B (58 trumpet players).	Clarinet players had higher pulmonary functions than trumpet players.	Group A spirometry: FVC - 108.66 ± 12.17 FEV1 - 110.34 ± 11.48 FEV1/FVC - 101.74 ± 4.95 Group B: FVC - 104.17 ± 13.03 FEV1- 105.89 ± 11.53 FEV1/FVC - 102.03 ± 4.75
Deniz et al.[10]	To compare the lung function of Turkish military band brass musicians with naval officers	N = 78, being 34 military band brass musicians and 44 healthy naval officers (non-musicians)	Pulmonary function test parameters were decreased in brass players in a military band. Wind instrument classes, such as brass or wood, had no additional effect on lung function.	Spirometry Group Case: FVC 95.83 ± 6.46 FEV1 93.28 ± 9.80 FEV1/FVC - 97.38 ±7.96 Group control FVC - 99.50 ± 7.54 FEV1- 103.56 ± 6.84 FEV1/FVC - 104.02 ± 4.76
Hahnengress & Bönng[13]	Investigate cardiopulmonary parameters during the performance of clarinetist professionals	N = 15 clarinetists (8 women, 7 men) volunteered in the experiment after informed consent	Average heart rate increased to values during moderate to intense physical exercise, depending on the artistic intensity and difficulty of the movement. The electrocardiogram showed no pathological events. Playing the clarinet professionally puts more pressure on ventilation and circulation, but generally not at a pathophysiological level.	Spirometry Case Group: FVC 4.67 ± 1.07 FEV1 4.11 ± 0.83 Peak flow Control group PEF 9.25 ± 1.79 It does not demonstrate values for the control group, and it only

Table 4 — Characteristics of the studies that examined the pulmonary function in wind instrumentalist musicians (cont.).

Study	Objectives	Sample	Results	Medium values
				reports that they were slightly higher than the calculated values of age, gender, weight and height.
Subramanian et al.[11]	To assess pulmonary functions and the risk of developing obstructive sleep apnea (OSA) in wind instrumentalists	N= 129, 64 wind instrumentalists and 65 from the control group	There is no association between improved lung function and reduced risk of developing OSA, although the risk of OSA is reduced in wind instrument players. Therefore, playing wind instruments can be considered an option to reduce the risk or treat OSA	Spirometry Group Case: CVF - 111±90.12 FEV1 - 76.7±30.65 FEV1/FVC - 81.85±29.01 Group control FVC - 71.2 ± 20.33 FEV1 - 68.73 ± 29.43 FEV1/FVC - 97.9 ± 29.87
Studer et al.[12]	Investigate the effect of playing the trumpet/cornet/flugelhorn on lung function.	N = 147, with 99 trumpet/cornet/ *fluegelhorn* players and 48 controls.	There was no significant difference in predicted FEV1% or predicted FVC% between groups. There was also no association between FEV1/FVC and trumpets/horns/horns or controls using linear regression and adjustment for age, sex, smoking status and BMI.	Spirometry Case Group: FVC - 4.3 ± 0.8 FEV1 - 3.5 ± 0.7 FEV1/FVC - 81.7 ± 5.9 Control Group FVC - 4.7 ± 0.8 FEV1 - 3.9 ± 0.7 FEV1/FVC - 83.6 ± 6.0
Brzęk et al.[14]	Describe basic spirometric parameters for wind instrument players and the causes of possible changes.	N = 65, 31 musicians (group A) and 34 control group (group B).	spirometric parameters related to the patterns can prove a good breathing capacity. Peak expiratory flow (PEF) and FEV1 may indicate that proper breathing technique during performance has been acquired. The playing time of the wind instrument can influence the parameters of dynamic spirometry	Spirometry Case Group: FVC - 90.54 ± 5.62 FEV1 - 103.54 ± 12.54 FEV1/FVC - 108.03 ± 8.38 Group control FVC - 102.07 ± 11.97 FEV1- 95.81 ± 16.64 FEV1/FVC - 100.07 ± 10.35
Granell et al.[15]	To analyze lung function in young people in a learning period, considering their level of physical condition	N = 90; 32 wind instruments and 58 other instruments	The study of wind instruments was associated with an obstructive spirometric pattern in young musicians with an average level of physical fitness	Spirometry Case Group: FVC - 95.55 (91.61 — 99.49) FEV1 - 85.72 (82.41 — 89.01) FEV1/FVC - 0.77 (0.74 — 0.79) Group control CVF - 98.58 (95.84 — 101.33) FEV1- 100.89 (97.34 — 104.44) FEV1/FVC - 0.86 (0.85 - 0.88)
Soria et al.[16]	To assess expiratory flows in brass musicians and assess whether this data can be used to draw conclusions about the safe distance	N = 46, 27 musicians and 19 control subjects.	It was observed that FVC, FEV1 and PEF had lower values in the group of musicians. The Tiffeneau index (FEV1/FVC ratio) in both groups remained within physiological normality without significant differences.	Spirometry Case Group: FVC - 4.61 ± 0.68 FEV1 - 4.16 ± 0.68 FEV1/FVC - 87.62 ± 8.1

Table 4 — Characteristics of the studies that examined the pulmonary function in wind instrumentalist musicians (cont.).

Study	Objectives	Sample	Results	Medium values
	health authorities are currently recommending to protect against COVID-19.			Control Group FVC - 5.28 ± 0.9 FEV1- 4.66 ± 0.75 FEV1/FVC - 88.59 ± 5.16
Schorr-Lesnick et al.[17]	To assess whether lung function in singers and wind instrument players can be better than normal control subjects	N = 113, 34 singers and 48 wind instrumentalists, with a control group of 31 string or percussion instrumentalists.	They found no significant difference between groups in maximal voluntary ventilation, forced expiratory volume in one second (FEV1), forced vital capacity (FVC), mean forced expiratory flow during the middle half of FVC, FEV1/FVC, peak expiratory pressure, or peak inspiratory pressure.	Spirometry Group Case: FVC – 98.7 ± 13.1 FEV1 – 103.5 ± 15.5 FEV1/FVC – 78.0 ± 6.8 Group control FVC – 97.2 ± 13.8 FEV1 - 101.9 ± 17.6 FEV1/FVC – 79.1 ± 9.4

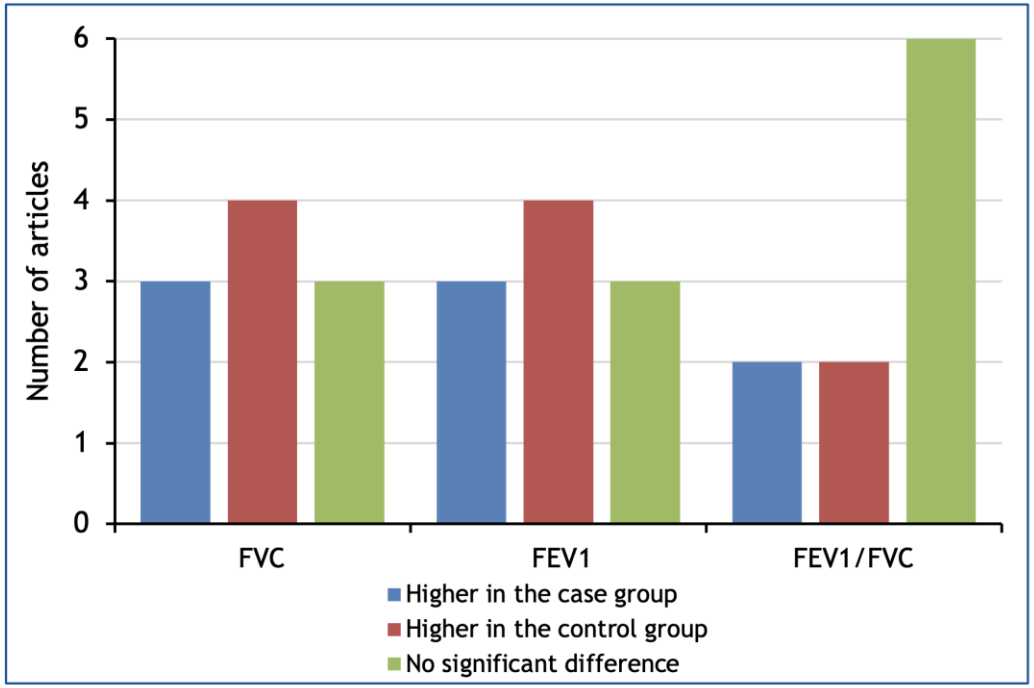

Figure 2 — Spirometric values - shows three variables of interest evaluated by spirometry and separates how many articles presented higher values in each variable. Forced vital capacity (FVC): represents the maximum volume of air exhaled with maximum effort from the point of maximum inspiration. The forced expiratory volume in the first second (FEV1) is the amount of air eliminated in the first second of the forced expiratory maneuver. FEV1/FVC ratio - the ratio between forced expiratory volume in the first second and forced vital capacity, being very important for diagnosing an obstructive disorder.

The strength of the respiratory muscles of wind musicians showed no significant difference compared with that of healthy individuals, according to Antoniadou et al. (2012)[8]. However, when the instruments were analyzed separately, the PImax and PEmax values were higher in trumpet players. The increase in PEmax may be related to the years of playing the wind instrument due to the exercises performed by musicians against the instrument's high resistance, mainly the expiratory muscles. In contrast, Smith et al.[6] reported no difference in the PImax of musicians compared with the control group and in any specific instrument in which the PImax value was higher than the control group.

Fuhrmann et al. (2009)[18] described the prevalence of activity-related diseases. According to the authors, the type of instrument played and the level of experience with the instrument were not associated with the prevalence of asthma among musicians. In both beginning students and the highest levels of musicality (i.e., among professional musicians), the results generally showed no difference in the prevalence of asthma/wheezing between the brass and woodwind subgroups. Furthermore, the prevalence of asthma and wheezing among these musicians was similar to that of the general population.

Our work has some limitations. Some studies showed critical methodological flaws, such as the lack of matching between the control and case groups or the inclusion of smokers among the study participants, which may have impacted the results. Another limitation was that, although we tried to contact the authors of two articles, we received no response, which could have modified the results. However, a relevant point in our study was the critical analysis of the articles published in the area and their limitations, which will raise new investigations with better specific methodological designs aimed at this public. There is a need for studies with better methodological designs, more specific aspects of this relationship between lung function and wind instruments, and its impact on patients with some previous lung disease.

CONCLUSION

It was observed with this integrative review that, in most studies, musicians had lower values in spirometry (FEV1 and FVC) than the control group. However, there was no difference in FEV1/FVC, just as there was no difference in respiratory muscle strength or relationship with respiratory diseases.

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Individual contribution of the authors:
Conception and design of study: VPL, IPS
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