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Respiratory function in vocal soloists, opera singers and wind instrument musicians

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Musician; wind instruments; opera singer; respiratory function

Parole chiave
Musicista; strumenti a fiato; cantante d'opera; funzione respiratoria

Summary
Introduction: *Current studies have not yet reached a definitive conclusion on the effects of singing and playing wind instruments professionally on an individual's respiratory function.* **Objective:** *The purpose of this study was to investigate the respiratory function of wind instrument players and opera singers in comparison with a group of healthy individuals.* **Methods:** *The experimental group comprised 45 men and 35 women, 58 opera singers and vocal soloists in total and 22 wind instruments players. Eighty controls were all non-smokers, healthy individuals, matched for age and sex. Spirometry was performed with a dry spirometer, according to the American Thoracic Society recommendations.* **Results:** *The mean age of the experimental group was 47.9 (15.5) years for men and 46.6 (16.8) for women. Experimental group and controls differed (p<0.01) in FVC [%predicted values: 98.69±13.07 vs 89.62±14.01 (men), 104.2±17.7 vs 93.8±13.9 (women)], FEV_1[% predicted values: 98.69±13.07 vs 89.62±14.01 (men), 104.2±17.7 vs 93.8±13.9 (women)] and in PEFR values (p=0.001). [100.4±18.8 vs 76.7±19.8 (men)]. FEV_1/FVC ratio significant differences were detected only in women (p=0.001, for predicted values).* **Conclusion:** *The findings of the present study provide evidence that professional involvement with wind musical instrument or monody might have beneficial effects on respiratory function. Future therapeutic perspectives, and associations between a documented improved respiratory function and performance by the musician should be examined.*

Riassunto
«La funzione respiratoria in cantanti solisti, cantanti lirici e musicisti di strumenti a fiato». **Introduzione:** *Gli studi condotti non hanno raggiunto conclusioni definitive circa gli effetti sulla funzione respiratoria del cantare e del suonare uno strumento a fiato professionalmente.* **Obiettivo:** *Scopo dello studio è di investigare la funzione respiratoria dei suonatori di strumenti a fiato e dei cantanti lirici a confronto con quella di un gruppo di controllo composto di individui sani.* **Metodi:** *Il gruppo sperimentale comprendeva 45 uomini e 35 donne, di cui 58 tra cantanti d'opera e solisti, e 22 strumentisti. Il gruppo di controllo era compost di 80 individui non fumatori, sani, omogenei per età e sesso. La spirometria è stata condotto con uno spirometro a secco seguendo le raccomandazioni dell'American Thoracic Society.* **Risultati:** *L'età media del gruppo sperimentale era di 47,9 (15,5) anni per gli uomini*

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e di 46,6 (16,8) per le donne. Il gruppo sperimentale e quello di controllo differivano (p<0.01) nei valori FVC [% valori predetti: 98.69±13.07 vs 89.62±14.01 (uomini), 104.2±17.7 vs 93.8±13.9 (donne)], FEV_1[% valori predetti: 98.69±13.07 vs 89.62±14.01 (uomini), 104.2±17.7 vs 93.8±13.9 (donne)] e nei valori PEFR (p=0.001). [100.4±18.8 vs 76.7±19.8 (uomini)]. Differenze significative nel rapporto FEV_1/FVC sono stati riscontrati solo nelle donne (p=0.001, per valori predetti). **Conclusioni:** *Il presente studio indica che cantare o suonare strumenti a fiato in maniera professionistica produce effetti benefici sulla funzione respiratoria. Prospettive terapeutiche future e l'associazione tra una documentata migliore funzione respiratoria e una migliore performance del musicista andrebbero indagate.*

Abbreviations
FEV1: Forced expiratory volume in 1 second
FEF: Forced expiratory flow
FVC: Forced vital capacity
MVV: Maximum voluntary ventilation
PEFR: Peak expiratory flow rate
FEF25%, FEF50% FEF75%: forced expiratory flow rates at 25, 50 and 75% of FVC expired
RV: Residual Volume
TLC: Total lung capacity
TV: Tidal volume
VC: Vital Capacity

Introduction

Wind instrument musicians and vocal soloists need to maximise the use of their respiratory reserves and technical skills in order to achieve the best performance result. While performing music or vocal exercises, the performers significantly exercise their expiratory respiratory muscles. This systematic training-strengthening of the respiratory muscles has led to the formulation of the hypothesis that wind instrument musicians and vocalists have better respiratory function compared to non-musicians, although there are conflicting results in the literature (1, 2, 5). The respiratory function in vocal soloists and wind instrument musicians has not been studied in detail and there is insufficient data on the relationship between lung volume and the performance of singers and musicians.

Stauffer in his study (16), which included 63 professional wind instrument musicians and 17 opera singers of the US Navy band, found that on average the vital capacity of the musicians was increased by 0.38 lt (or 8.7% compared with the predicted values), while the "average" musician was 1.81 m tall and 26.5 years old. Khuje and Hulke (10), who included in their study 100 wind instrument musicians and 100 people as a control group, also recorded higher values of FVC, FEV_1, FEF 25-75% and MVV compared with the control group, which were attributed to the special breathing described above (deep breath followed by a long exhalation), while higher MVV was attributed to the strengthening of respiratory muscles due to their professional engagement with music.

However, there are studies with contrary results that did not show significant difference in lung function between wind instrument musicians and non-wind instrument musicians nor did they record lower values of respiratory parameters. The study of Schorr-Lesnick (15), involving 113 musicians (48 wind instrument musicians, 34 opera singers and 31 string and percussion instrument musicians as a control group) compared spirometric values, maximal mouth pressures, the presence of symptoms of respiratory system and general health status, as this was recorded in a self-report questionnaire. No differences were found in spirometry values (although slightly higher FVC values were observed in the group of opera singers compared to the control group) and maximal mouth pressures among the three groups, even after their reduction in terms of body mass index (BMI), years of experience, smoking habits and presence of respiratory symptoms. Nevertheless, opera singers seemed to pay more attention to their general health status as they practiced more and smoked less than the other two groups.

In addition, monody and wind instrument teachers are not familiar with the physiology of the respiratory system and the corresponding terminology,

and consequently the integration of relevant knowledge in daily practice is difficult, while the concept of the respiratory system is limited to purely respiratory anatomic components, with artists often ignoring basic components of the respiratory function. The simplification that breathing in opera singers means simply providing air for vocalization downplays the fact that the respiratory function works as a connecting link between vocalization, emotion and music, a role that is central to monody and its teaching. The most common assessment of breathing is lung volume and vital capacity, by asking the opera singer to inhale as much as they can and then exhale to maximal expiratory position. The measurement of lung volumes at the beginning and the end of the verse is considered essential for the singer. Singers generally start phrases at 70-80% VC and end phrases at 30-50% VC. The range of fluctuation varies from opera singer to opera singer, but it has been found to remain remarkably stable in the same opera singer (3, 8, 9, 17, 18).

The purpose of this study was to investigate the respiratory function of wind instrument players and opera singers in comparison with a control group of healthy individuals.

Methods

The experimental group comprised 45 men and 35 women, 58 opera singers and vocal soloists in total and 22 wind instruments players. Sample size was calculated with Gpower 3.0 software, for significance level α=0.05, power level =0.95 and effect size equal to 0.5. Experimental and control group comprised 80 subjects each, matched for age and sex. Controls were all non-smokers, healthy individuals. All participants were Caucasian, of Greek ethnicity. No participant has been an athlete or reported any strenuous systematic physical activity. Wind instrument players were all professionals and they enrolled in the study regardless of their wind instrument, while opera singers and vocal soloists had at least a five-year experience of systematic performing. Participants volunteered to enter the study. Participants were informed that data were for scientific use only.

A self-assessment questionnaire was first completed by all subjects, which included questions about smoking habits, the presence of comorbidities. Individuals with any acute or chronic respiratory disease were excluded from the study. The identification of comorbidities was based on the health records of each patient and the type of drugs received. The subjects were subsequently submitted to physical examination, including the assessment of their body mass index (BMI) and spirometry. The BMI was calculated as the body weight divided by the square of height (expressed in kg/m^2). Subjects with a history of >100 cigarettes during lifetime were considered as smokers.

Spirometry was performed with a dry spirometer (Spirulab II), according to the American Thoracic Society recommendations. Software incorporated universal equations and adjusted automatically for somatometric characteristics, according to ERS guidelines (13). These ERS/ECCS 1993 regressions published by the European Respiratory Society (ERS) and are also identified by the ATS/ERS Task Force: 2005 "Standardization of Lung Function Testing" for Europeans. They are used all over Europe and elsewhere (12). Calibration checks were performed every morning, 30 minutes before the beginning of the spirometry program. Forced expiratory maneuvers were repeated until two reproducible acceptable tests were obtained and the best forced expiratory volume in the 1st second (FEV_1), forced vital capacity (FVC), and FEV_1 to FVC ratio (FEV_1/FVC) values were recorded. Spirometry was performed during rehearsals or at music schools.

Ethics

University of Thessaly bioethics committee approved the study, according to the Helsinki Declaration of Ethical Principles for Medical Research Involving Human Subjects.

Results

The mean age of the experimental group was 47.9 (15.5) years old for men and 46.6 (16.8) for women. The BMI values were 27.2 (5.0) kg/m^2 and 24.0

(3.0) kg/m^2 respectively. Thirteen men (28.9%) and 7 women (20.0%) were current smokers. Arterial Hypertension was the most frequent comorbidity (20% in men and 11.4% in women) (table 1).

Singers and wind instrument players did not differ regarding spirometry values, although men wind instrument players did exhibit a tendency towards higher FEV_1 values, compared to their singer counterparts (p=0.099) (table 2).

Experimental group and controls differed in FVC and FEV1 values (best actual and predicted-p=0.002 and p=0.008 respectively for FVC, p=0.009 and p=0.023 respectively for FEV1) and in PEFR values (men in both actual and predicted, women in actual only-p=0.001). Regarding the FEV_1/FVC ratio, differences were detected only in women (p=0.001, for predicted values) (table 3).

The mean value of the years of performance/training was 24.64±4.24 years.The number of the years of musical performance was not correlated with any of the respiratory paramaters: FVC (r=-0.144, p=0,201); FVCpred (r=-0.150, p=0.184); FEV_1 (r=-0.174, p=0.123); FEV_1pred (r=-0.146, p=0.196); FEV_1/FVC (r=-0.114, p=0.314); FEV_1/FVCpred (r=-0.075, p=0.514); PEFR (r=-0.075, p=0.510); PEFRpred (r=-0.033, p=0,774). When the variable "years of performance" was dichotomized around its mean (27yrs), those musicians/singers with less or equal to 27 years of performance did not differ in any respiratory parameter compared with those with longer duration (>27yrs): FVC (p=0.832); FVCpred (p=0.214); FEV_1(p=0.789); FEV_1pred (p=0.284); FEV_1/FVC (p=0.478); FEV_1/FVCpred (p=0.819); PEFR (p=0.219); PEFRpred (p=0.411).

Discussion

The findings of the present study support the view that professional involvement with wind musical instrument or monody has beneficial effects to respiratory function. Moreover, vocalists and musicians seem to derive equal benefit from their professional activities, although wind instrument players did show some better FEV_1 performance.

Most previous studies are in accordance with our findings, suggesting a better respiratory function for wind instrument players and vocalists, compared to various control groups. The study of Sagdeo and Khuje (14), included 155 trained professional wind

Table 1 - Experimental group features

	Study sample		Controls	
	Men (N=45) Mean (SD)	Women (N=35) Mean (SD)	Men (n=45) Mean (SD)	Women(n=35) Mean (SD)
Age (years)	47.9 (15.5)	46.6 (16.8)	48.2 (14.2)	47.7 (15.1)
BMI (kg/m2)	27.2 (5.0)	24.0 (3.0)	26.3 (3.4)	24.5 (4.4)
Height (m)	1.77 (0.06)	1.64 (0.04)	1.75 (0.07)	1.66 (0.06)
Weight (Kg)	85.8 (17.7)	64.9 (9.5)	80.8 (12.8)	67.5 (9.6)
	N (%)	N (%)		
Smoking				
Smokers (current)	13 (28.9)	7 (20.0)		
Ex-smokers	13 (28.1)	3 (8.6)		
Never-smokers	19 (42.2)	25 (71.4)		
Comorbidities				
AH	9 (20.0)	4 (11.4)		
DM	1 (2.2)	2 (5.7)		
Hyperlipidemia	1 (2.2)	1 (2.9)		

SD: standard deviation; AH: Arterial Hypertension; DM: Diabetes Mellitus

Table 2 - Respiratory function in men (singers vs blowers)

	Men			Women		
	Opera singers/ Vocal soloists (N=32) Mean (SD)	Wind instrument players (N=13) Mean (SD)	p	Opera singers/ Vocal soloists (N=26) Mean (SD)	Wind instrument players (N=9) Mean (SD)	p
FVC (L) (best)	4.3±0.8	4.7±0.7	0.193	3.4±0.7	3.6±±0.4	0.292
FVC (% pred)	97.1±12.5	101.1±11.9	0.335	102.0±15.2	98.1±7.7	0.475
FEV1 (L) (best)	3.51±0.8	4.0±0.7	0.099	2.8±0.6	3.1±0.5	0.323
FEV1 (pred)	97.5±16.0	102.9±14.7	0.290	96.6±12.9	97.3±13.7	0.303
FEV1/FVC (best)	0.81±0.1	0.84±0.1	0.180	0.82±0.1	0.85±0.1	0.231
FEV1/FVC (%pred)	102.9±10.38	104.9±7.07	0.535	104.9±7.2	103.9±11.5	0.776
PEFR (L/s) (best)	9.2±1.9	9.4±2.3	0.714	6.5±1.1	6.2±0.9	0.665
PEFR (%pred)	102.8±18.4	100.6±22.9	0.772	90.3±8.9	88.4±10.4	0.780

Table 3 - Respiratory function in men and women (singers/blowers vs controls)

	Men			Women		
	Opera singers/ Vocal soloists/ wind instrument (N=45) Mean (SD)	Control group (45) Mean (SD)	p	Opera singers/ Vocal soloists/ wind instrument players (N=35) Mean (SD)	Control group (35) Mean (SD)	p
FVC (best)	4.52±0.84	3.85±0.84	0.002	3.4±0.6	2.9±0.7	0.010
FVC (pred)	98.69±13.07	89.62±14.01	0.008	104.2±17.7	93.8±13.9	0.005
FEV1 (best)	3.71±0.88	3.16±0.74	0.009	2.9±0.6	2.5±0.6	0.005
FEV1 (pred)	100.05±16.50	90.65±16.21	0.023	100.7±14.18	92.4±13.5	0.012
FEV1/FVC (best)	0.82±0.08	0.82±0.09	0.843	0.83±0.1	0.84±0.1	0.663
FEV1/FVC (pred)	104.08±9.80	100.96±9.42	0.199	106.18±8.86	98.95±7.99	0.001
PEFR (best)	8.9±2.0	6.6±2.0	<0.001	6.3±0.9	5.3±1.2	0.008
PEFR (pred)	100.4±18.8	76.7±19.8	<0.001	88.9±9.6	81.2±15.8	0.125

instrument musicians, 100 untrained amateur musicians and 100 other instrument musicians. The musicians of the first group showed higher values of FEV_1, FVC, PEFR, MVV and $FEF_{25-75\%}$ compared to the other two groups, with no recorded difference in FEV_1/FVC. The researchers concluded that systematic training-practice with wind instruments improves lung function indices, which can be considered an additional advantage of the training with wind instruments. Duhle et al (4), found improved lung function by increasing the FVC and the PEFR in 30 different wind instrument musicians compared to 30 healthy controls, non-smokers. In fact, they suggested the therapeutic use of wind instruments in respiratory diseases. According to Zuskin et al (19), who studied 99 wind instrument musicians and 41 stringed instrument musicians (smokers and non-smokers), wind instrument musicians showed statistically significantly higher FEV_1 values (smokers or non-smokers), as well as $FEF_{50\%}$ (non-smokers only) compared with the predicted values for their sex and age (however, there was no comparison with the control group). The recorded increase in FEV_1 and $FEF_{50\%}$ was proportional to their

years of service as professional musicians. Khuje and Hulke (10), who included in their study 100 wind instrument musicians and 100 people as a control group, also recorded higher values of FVC, FEV1, FEF 25-75% and MVV compared with the control group, which was attributed to the special breathing described above (deep breath followed by a long exhalation), while higher MVV was attributed to the strengthening of respiratory muscles due to their professional engagement with music.

Some researchers argue that choral singing has beneficial effects on respiratory function (3, 6, 18). The study by Daugherty (3) involved sixty patients with asthma in a program of weekly respiratory fitness sessions, song and song-breaths during 4 weeks. Subjects at the end of 4 weeks showed a significant increase in peak inspiratory flow and improvement in their quality of life. Watson and Hixon (18) showed that the gradual learning of an aria by a baritone until its execution before an audience resulted in an increase of vital capacity by 17%.

However, there are few studies with contrary results that did not show significant difference in lung function between wind instrument musicians and non-wind instrument musicians nor did they record lower values of respiratory parameters. In the study of Schorr-Lesnick (15), involving 113 musicians (48 wind instrument musicians, 34 opera singers and 31 string and percussion instrument musicians as a control group) no differences were found in spirometry values (although slightly higher FVC values were observed in the group of opera singers compared to the control group). In the study by Fuhrmann et al, which involved 102 individuals (55 brass wind instrument musicians and 47 musicians of other instruments, no difference was recorded in the values of spirometry or lung volumes between the two groups, except for the RV/TLC ratio, which was lower in wind instrument musicians (7). In the study by Heller et al, the tidal volume, the vital capacity, the total and remaining capacity were measured in 16 professional opera singers and 21 control subjects who had not received any professional vocal training. There was no difference between them both in the supine and the upright position, which could not be attributed to age, anthropometric characteristics or measurement errors (9).

Regarding years of experience, the fact that most participants had quite a long period of practice and performance in their past might have masked any effect of performance duration on respiratory function, as almost all musicians may have benefited a lot after a long period of training.

This study comprised one of the largest number of volunteers ever enrolled in similar surveys, even though larger samples might be necessary for smaller effect size. Nevertheless, if some additional testing were performed, it would have helped to further elucidate our results. In that context, FEF25-75% and TLC and/or respiratory muscle pressures, if recorded, could have provided additional information of the respiratory physiology of our participants. A detailed recording of musical activity duration and correlation with lung function might have improved our results interpretation. Moreover, universal equations and norms might not be absolutely suitable for Greek or other ethnicities (11, 19).

So far, the studies carried out have not reached any definitive conclusions regarding the effect of professional involvement with wind musical instrument or monody in respiratory function. However, the effects on the respiratory function vary, but most of them are beneficial, while it is stressed that music is always beneficial to a person's general health status. The relatively few studies available in the literature, the rather small number of wind instrument musicians involved, and the practical difficulties in the studies (from the voluntary participation to the variety of instruments and requirements of the respiratory system) may be responsible for the lack of definitive conclusions.

However, one point that deserves particular investigation is the differences between musicians dealing with various wind instruments, as the instruments that require higher pressures have increasing demands for the musicians and their respiratory system. It is therefore more likely to cause changes in lung function. Future therapeutic implementation for respiratory function improvement through singing exercises and associations between music performance and improved respiratory function should be examined. Future studies that will include a larger number of musicians and opera singers may have stronger statistical power, and could provide

more data regarding the comprehensive study of the respiratory function of wind instrument musicians and vocal soloists.

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