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Respiratory function in wind instrument players

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Key words
Wind instrument players; respiratory symptoms; lung function

Summary
Background: *The playing of wind instruments has been associated with changes in respiratory function.* **Study objectives:** *To investigate the effect of playing wind instruments on lung function and respiratory symptoms.* **Methods:** *The present study included 99 wind instrument players and a group of 41 string instrument players as a control from 3 major orchestras in Zagreb, Croatia. Data on chronic respiratory symptoms were recorded in all studied subjects. Lung function was measured in wind instrument players by recording maximum expiratory flow-volume curves.* **Results:** *Wind instrument players demonstrated significantly higher prevalences of sinusitis, nasal catarrh and hoarseness compared to control musicians. One wind instrument player developed asthma associated with his work. Odds ratios for wind instrument players were significant for chronic cough, chronic phlegm and chronic bronchitis by smoking habit ($p<0.05$ or $p<0.01$) but not for length of employment. Ventilatory capacity data indicate that wind instrument players had significantly greater FEV1 (smokers and nonsmokers) as well as FEF50 (nonsmokers) ($p<0.05$) compared to predicted values. Regression analysis of pulmonary function tests in wind instrument players demonstrate a significant link between FEV1 and FEF50 and length of employment. Those wind instrument players with longer employment had the greatest increases in lung function.* **Conclusions:** *Our data suggest that musicians playing wind instruments may be susceptible to chronic upper airway symptoms. Interestingly wind instrument playing may be associated with higher than expected lung function parameters.*

Riassunto
«Funzione respiratoria in suonatori di strumenti a fiato». *I suonatori di strumenti a fiato possono andare soggetti ad una compromissione della funzione respiratoria collegata alla loro attività. Al fine di valutare i possibili effetti dell'uso professionale di strumenti a fiato sulla funzione polmonare, abbiamo studiato un gruppo di 99 suonatori di strumenti a fiato dell'Orchestra Militare di Croazia, dell'Orchestra Filarmonica e dell'Orchestra del Teatro Nazionale, mentre 41 suonatori di strumenti ad arco costituivano il gruppo di controllo. L'anamnesi per i sintomi respiratori cronici è stata raccolta in tutti i soggetti studiati. La funzionalità polmonare dei suonatori di strumenti a fiato è stata valutata misurando le curve di flusso-volume espiratorio massimo, sulle quali sono stati misurati la capacità vitale forzata, il volume espiratorio forzato in un secondo (FEV1) ed il massimo flusso espiratorio al 50% ed al 25% (FEF50, FEF25). I suonatori di strumenti a fiato hanno messo in luce una significativa prevalenza di sinusite, di catarro nasale e di raucedine rispetto ai suonatori di controllo. Uno dei suonatori di strumenti a fiato ha*

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sviluppato asma associata alla propria attività. L'odds ratio per i suonatori di strumenti a fiato è risultato significativo per tosse cronica, catarro cronico e bronchite cronica in conseguenza dell'abitudine al fumo di tabacco ($p<0.05$ o $p<0.01$), ma non per l'anzianità lavorativa. Lo studio della capacità ventilatoria nei suonatori di strumenti a fiato ha messo in luce valori significativamente più alti del FEV1 (fumatori e non fumatori) e del FEV50 (non fumatori) ($p<0.05$) rispetto all'atteso. L'analisi di regressione delle funzioni polmonari nei suonatori di strumenti a fiato ha dimostrato l'esistenza di un rapporto significativo tra FEV1 e FEV50 e anzianità lavorativa. I suonatori a fiato con maggior anzianità lavorativa presentavano il maggior incremento delle funzioni polmonari. Questi dati suggeriscono che i suonatori di strumenti a fiato possono essere più suscettibili a sviluppare sintoni cronici delle vie aeree superiori. Appare anche che lo suonare strumenti a fiato può essere associato a valori più alti dei parametri delle funzioni polmonari rispetto all'atteso.

Introduction

As early as the eighteenth century Ramazzini (27) described diseases in voice-trainers, singers, and in other instrumentalists. Recently there has been increased attention towards the medical problems of musicians. Levine (18) described some pathological disorders associated with playing wind instruments, such as subcutaneous emphysema of the head, neck and parotid; paralysis of the palate; patulous Eustachian tubes; laryngocele and pharyngocele. Evers et al (10) reported ischemic stroke due to carotid artery dissection occurring during wind instrument playing believed to be caused by increased intrathoracic and consequent intrapharyngeal pressure. A poor breathing technique on any wind instrument breaks up the shape and flow of a solo. Saxophonists often use circular breathing technique to produce seamless air streams, inhaling through the nose while simultaneously inflating the cheeks with air which is a demanding and possibly dangerous exercise (17, 35). Recently, Aydin et al (3) reported that wind instrument playing may significantly increase intraocular pressure in healthy players. Recently, Deniz et al (9) reported reduced pulmonary function in wind instrument players and concluded that pulmonary function in wind instrument players might be diminished because of the development of asthma or constant barotraumas during playing.

Playing a wind instrument requires the coordination of diaphragmatic motion, adjustment of lung volume, skilled breathing control, adequate patency and humidity of the air passages and precise coordination of the muscles of the oropharyngeal cavity (12). Akgun and Ozgonul (1) reported that in certain wind instrument (zurna) players lower vital capacity, total lung capacity, maximal breathing capacity, and maximal expiratory and inspiratory flow rates, along with an increase in functional residual capacity and RV/TLC ratio were found. Schorr-Lesnick (31, 32) studied string and percussion instrument players, as well as wind instrumentalists and vocalists. The author found that vocalists had a lower incidence of respiratory disease and less absenteeism resulting from respiratory disorders than other musicians. In their study pulmonary function in wind instrumentalists appeared to be unaffected (14).

In the current study we investigated lung function and respiratory symptoms in two groups of musicians, those playing wind instruments and those playing string instruments.

Subjects and methods

Subjects

Our present study included a group of 99 male wind instrument players. There are only a few women wind instrument players in these orchestras and they were not studied. The studied musicians represented 98% of all the male musicians employed in the three orchestras as wind instrument

musicians in Zagreb (Croatian Military Orchestra, Zagreb Philharmonic Orchestra, National Theatre Orchestra). The mean age of the wind instrument players was 35 years (range: 21 to 61 years), their mean height was 178 cm (range: 155 to 188 cm) and their mean duration of employment was 20 years (range: 2 to 40 years). Thirty-six of the musicians were smokers (36/99; 36.4%) smoking on average 20 packs/year.

A group of 41 male musicians playing string instruments was studied as controls for the prevalence of chronic respiratory symptoms. The age, duration of employment and smoking habits were not significantly different between these two groups. Their mean age was 33 years (range: 20 to 60 years), mean height 175 cm (range: 157 to 185 cm) and the mean duration of employment was 19 years (range 2 to 42 years).

Respiratory symptoms

Chronic respiratory symptoms were recorded using the British Medical Research Council questionnaire on respiratory symptoms (6) with additional questions on occupational asthma (13, 20, 36). In all the musicians a detailed occupational history as well as questions about smoking habits were recorded. The following definitions were used:

Chronic cough or phlegm: cough and/or phlegm for a minimum of three months a year;

Chronic bronchitis: cough and phlegm for a minimum of three months a year and for not less than 2 successive years;

Dyspnea grades: grade 3 - shortness of breath when walking with other people at an ordinary pace on level ground; grade 4 - shortness of breath when walking at their own pace on level ground;

Occupational asthma: recurring attacks of dyspnea, chest tightness and pulmonary function impairment of the obstructive type diagnosed by physical examination and spirometric measurements and confirmed by medical records;

Acute symptoms that developed during performance were also recorded, including cough, dyspnea, chest tightness, and irritation or dryness of the throat.

Ventilatory capacity

Ventilatory capacity measurements were performed by recording the maximum expiratory flow-volume (MEFV) curves on a spirometer Pneumoscreen (Jaeger, Wurzburg, Germany). The same instrument and technicians were used in both groups of musicians. The forced vital capacity (FVC), the one-second forced expiratory volume (FEV1), and the maximum expiratory flow rates at 50% and the last 25% of the vital capacity (FEF50, FEF25) were measured on the maximum expiratory flow-volume (MEFV) curves. Measurements were made during the morning performances or rehearsals. The spirometer was calibrated on a daily basis. Lung function testing was performed according to the recommendations of Quanjer et al (24). At least three MEFV curves were recorded for each subject and the best value of the three technically satisfactory reproducible MEFV curves was used as the result of the test (this was the curve with the greatest FVC and FEV1). The measured values of ventilatory capacity were compared with the predicted normal values based on sex, age and height (25). Studies were performed using the same instrument and by the same technicians.

Statistical analysis

The Chi-square test (or where appropriate Fisher's exact test), was used for testing differences in the prevalence of chronic respiratory symptoms between groups. A level of $p < 0.05$ was considered statistically significant. Odds ratios were calculated by using a logistic regression analysis for each respiratory symptom (age, length of employment and smoking were the predictors (29). The results of ventilatory capacity measurements were analyzed by the paired t-test when comparing baseline to predicted values. Ventilatory capacity data were further analyzed by applying a multiple regression analysis with length of employment and smoking as predictors and FVC, FEV1, FEF50 and FEF25 as criteria variables (30). A level of $p < 0.05$ was considered statistically significant.

Results

Respiratory symptoms

Significantly higher prevalences of upper airway symptoms including sinusitis, nasal catarrh and hoarseness were noted in wind instrument players compared to the control group of string instrumentalist players ($p<0.01$). Among wind instrument players only one developed typical symptoms of occupational asthma (1.0%) following several years employment as a musician; none of the controls developed occupational asthma (NS).

The data on chronic respiratory symptoms according to smoking habits in wind instrument and string instrument players are presented in table 1. Wind instrument players, both smokers and nonsmokers, had higher prevalence of upper and lower respiratory symptoms than string instrument players. Additionally, smokers had higher prevalences than nonsmokers, particularly chronic cough, chronic phlegm and chronic bronchitis, but the differences were not statistically significant (NS).

Table 2 presents the results of a logistic regression analysis for individual symptoms in wind instrument players. The odds ratios for chronic cough, chronic phlegm and chronic bronchitis were significant according to smoking habits ($p <0.05$).

Ventilatory capacity

Ventilatory capacity data according to smoking habits in wind instrument players are presented in Table 3. Both smokers and nonsmokers had significantly increased FEV1 ($p <0.05$) compared to predicted values, whereas only nonsmokers had significantly increased FEF50 ($p <0.05$).

Table 4 shows the findings of the regression analysis of pulmonary function tests as a percentage of predicted values in the 99 male wind instrument players with length of employment and smoking as predictors and lung function parameters as outcome variables. Length of employment was significantly linked to FEV1 and FEF50 ($p <0.05$), with those musicians having worked the longest showing higher lung function measurements.

Discussion

Our findings indicate that wind instrument players had significantly higher prevalences of sinusitis, nasal catarrh and hoarseness than string instrument (control) players. A high prevalence of hoarseness (25.3%) among our wind instrument players and none among string instrument players

Table 1 - Chronic respiratory symptoms in 99 male wind instrument players and 41 string instrument players, by smoking habits

Group	Smoking habit	Age (yrs)	Employment (yrs)	Chronic bronchitis	Sinusitis	Nasal catarrh	Hoarseness
Wind instrument players	Smokers	29.0	15.3	5	10.0	9	10
	N=36	± 8.9	±7.9	13.9%	27.8%	25.0%	27.8%
				NS	NS	NS	NS
	Nonsmokers	39.0	23.0	3	12	13	15
	N=63	±13.3	±12.6	4.8%	19.0%	20.6%	23.8%
String instrument players	Smokers	31.1	17.5	2	1	1	0
	N=14	±9.8	±8.1	14.3%	7.1%	7.1%	0%
				NS	NS	NS	NS
	Nonsmokers	41.5	26.1	1	0	0	0
	N=27	±10.1	±6.5%	3.7%	0%	0%	0%

NS – difference not statistically significant ($p>0.05$)

Table 2 - *Respiratory symptoms in 99 male wind instrument players in relation to age, employment and smoking - logistic procedures*

Symptoms	Odds ratio		
	Age	Length of employment	Smoking
Chronic cough	1.034 (0.917-1.161)	1.015 (0.894-1.157)	4.922* (1.176-25.089)
Chronic phlegm	1.046 (0.925-1.181)	0.981 (0.859-1.120)	3.258* (1.788-15.256)
Chronic bronchitis	1.026 (0.889-1.174)	0.992 (0.853-1.155)	3.950* (1.780-25.062)
Occupational asthma	1.243 (0.778-2.273)	0.818 (0.447-1.347)	0 (0-18.832)
Dyspnea	1.051 (0.834-1.357)	0.929 (0.720-1.191)	1.185* (1.069-29.139)
Throat irritation	1.622* (1.068-3.547)	0.676 (0.338-1.010)	0 (0-6.252)
Dry throat	1.042 (0.663-1.565)	1.082 (0.743-1.850)	0 (0-25.111)
Nasal bleeding	0.608 (0.108-1.336)	1.073 (0.605-2.144)	0 (0-4.314)
Hoarseness	1.121* (1.019-1.244)	0.877 (0.783-0.974)	1.388* (1.010-3.958)
Nasal catarrh	1.028 (0.932-1.133)	0.966 (0.869-1.073)	1.297* (1.042-3.720)
Sinusitis	1.008 (0.913-1.109)	1.011 (0.912-1.125)	1.949* (1.065-5.852)

* Statistically significant ($p < 0.05$)
95% Confidence interval (C.I.) in brackets

Table 3 - Lung function in 99 male wind instrument players by smoking habit

Smoking	Mean age (yrs)	Mean height (cm)	FVC		FEV1		FEF50		FEF25	
			% predicted	Difference Measured/ predicted P	% predicted	Difference Measured/ predicted P	% predicted	Difference Measured/ predicted P	% predicted	Difference Measured/ predicted P
Smokers N = 36	29.0±8.9	179.0±7.6	98.2±14.3	NS	106.8±13.7	<0.05	103.4±23.1	NS	100.0±33.7	NS
Nonsmokers N = 63	39.0±13.3	178.0±7.2	101.9±15.2	NS	110.0±16.1	<0.05	107.4±30.0	<0.05	100.0±32.2	NS

The measured date are presented as mean ±SD
Difference measured / predicted (difference between actual measured lung function and calculated predicted value by paired t - test)
NS = difference not statistically significant (P >0.05)

Table 4 - *Regression analysis of pulmonary function tests as percentage of predicted values in 99 male wind instrument players*

Test	Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob>(T)	F	P	R^2
FVC	Intercept	1	98.6562	3.6186	27.263	0.0001			
	Employment	1	0.1938	0.1348	1.435	0.1546			
	Smoking	1	-1.9590	3.2630	-0.600	0.5497			
		1					1.650	0.1975	0.0131
FEV1	Intercept	1	104.9412	3.6805	28.513	0.0001			
	Employment	1	0.2589	0.1371	1.889	0.0519			
	Smoking	1	-3.1975	3.3188	-0.963	0.3377			
	1						3.144	0.0476	0.0419
FEF50	Intercept	1	98.9329	6.7089	14.747	0.0001			
	Employment	1	0.4158	0.2499	1.664	0.0595			
	Smoking	1	-2.6095	6.0496	-0.431	0.6672			
		1					1.897	0.0556	0.0180
FEF25	Intercept	1	102.0457	8.0527	12.672	0.0001			
	Employment	1	-0.0300	0.2999	-0.100	0.9204			
	Smoking	1	-3.1105	7.2614	-0.428	0.6693			
		1					0.092	0.9118	-0.0189

T - t- statistic for the null hypothesis
H0 - assumes the parameter to be 0

suggests that playing wind instruments may cause swelling of the vocal folds and upper respiratory tract mucosa resulting in hoarseness (15). Sinusitis was recorded in 22.2% of the wind instrument players. This again suggests irritation of the mucosa of the upper airways with blockage of the sinus drainage passages.

It appears from our data that musicians playing wind instruments may be more susceptible to chronic upper airway symptoms. Herer (16) (reported that singers and wind instrument players may be seriously impaired by respiratory problems that may not affect other musicians. Whereas Gilbert (12) reported that asthma is the most common chronic pulmonary disorder among wind instrument players, we found only one player with asthma.

Music therapy is a method which takes the advantage of therapeutic influence of music on vegetative, circulatory, respiratory and endocrine systems. Music therapy is treated as a method which complements conventional treatment (33). The Institute of music and musicians' medicine is a unique institution in Europe whose scope includes teaching and basics of music physiology and musicians¢ medicine and physiological and neurobiological principles of professional music performance and music perception (2).

Ventilatory capacity data in the wind instrument players indicates a significantly greater than predicted FEV1 in both smokers and nonsmokers as well as an increased FEF50 in nonsmoking wind instrument players ($p<0.05$) compared to predicted values. Regression analysis of pulmonary function tests in wind instrument players demonstrated a significant association between FEV1 and FEF50 with length of employment. Those wind instrument players with longer employment had the greatest increase in lung function. These data indicate that wind instrument playing may be associated with greater than expected lung function parameters. These data are similar to those reported by Bouhuys (4, 5) who studied lung function in wind instrument players and found that vital capacity was greater than expected. Other lung function results were similar to or better than those in control subjects.

There are several possible explanations for better lung function as compared to predicted in our wind instrument players. They are relatively young with short duration of employment. Although they are professional players, they do not play regularly every single day. In addition, they do not complain frequently of lower respiratory tract symptoms. The wind instrument players in our study might use a more correct and favourable breathing technique as well as a good coordination of chest movements during playing. In addition, in the healthy musicians, the smooth muscle strength during blowing enables opening of the smaller airways and in this way increases lung flow rates in smaller airways.

The lung function data in the wind instrument players can also be compared to the lung function in workers employed in the glassblowing industry. In a previous study of respiratory function in glassblowers (37) we demonstrated that these workers showed significant increases in FVC, FEF50 and FEF25 across the work shift, as well as increased pre-shift FVC and FEV1. In contrast, Navratil and Rejsek (22) showed in wind instrument players and glassblowers that blowing against a resistance does not lead to significant changes of ventilatory lung function.

Herer (16) described how music performance, especially by wind instrument players, depends on efficient pulmonary function. He also described the favorable effects of music on the respiratory system. A study by Lucia (19) suggested that playing wind instruments might have long-term potential benefits for asthmatics.

Several types of musical instruments involve changing the velocity and intensity of the expiratory flow. Fiz et al (11) demonstrated that for trumpet players, measured maximum respiratory pressures were greater than for people who do not play wind instruments. The authors explained that this probably occurred as a consequence of respiratory muscle training associated with wind instruments. A study by Smith et al (34) suggests that professional wind instrument players appear to have either inherent or acquired differences in respiratory perception and ventilatory neuromuscular control compared to healthy control subjects. Sapienza et al (28) suggested that there are simple methods of expiratory muscle strength training as an effective and efficient exercise for increasing expiratory muscle strength in instrumentalists. The study by Cugell (8) in brass instrument players showed that measurements of end-inspiratory lung volumes were much more consistent in the skilled players than in those who were novices.

The important role of the tongue during the act of blowing a wind instrument was described by Methfessel (21) who found significant differences between persons who play wind instruments and players of other types of instruments.

Histological examinations of the bronchial epithelium in nonsmoking wind instrument players have shown atypia of the bronchial epithelium (squamous metaplasia) in as many as 70% of these musicians (23). These authors proposed that in wind instrument players the lungs develop early emphysema as well as chronic bronchitis. These findings represent a chronic process that may result in a metaplastic transformation of the respiratory mucosa. Recently, Ruano-Ravina et al (26) reported that playing wind instruments, in addition to smoking, might be a risk factor in development of lung cancer.

Airway mechanics in wind instrument players have been compared to the respiratory and glottal measurements in normal, classically trained singers (7). Carroll et al (7) found that among singers there was an average FEV1 of 106.5% of the predicted value, an average FVC of 102.8% of the predicted values and an average FEF25-75 of 92.9% of the predicted value. Weikert and Schlomicher-Their (35) found that during saxophone playing the larynx is kept constantly in a low position, similar to that in singing. The larynx seems to participate actively in saxophone playing as it does in singing by regulating airflow.

In evaluating respiratory disorders of wind instrumentalists, it is important to obtain a history of the individual, including information about the working environment, playing technique and length of time they have played. In addition, symptoms of upper airway disease should be evaluated. In view of the finding that wind instrument players have higher than expected respiratory parameters,

normal or near normal lung function may not exclude early respiratory disease in these individuals. The workplace environment of the wind instrument players should be assessed for occupational hazards when managing these players, and smoking should in particular be discouraged. It remains to be seen whether differences in wind instruments, the mouthpieces used or the individual techniques of the player have any impact on the problems which may occur in wind instrument players.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

REFERENCES

1. AKGUN N, OZGONUL H: Lung volumes in wind instrument (zurna) players. Am Rev Respir Dis 1967; *96*: 946-951
2. ALTENMÜLLER E, KOPIEZ R, GREWE O, et al: The Institute for music physiology and musicians medicine. Cogn Process 2007; *8*: 201-206
3. AYDIN P. ORAM O, AKMAN A, et al: Effect of wind instrument playing in intraocular pressure. J Glaucoma 2000; *9*: 322-324
4. BOUHUYS A: Lung volumes and breathing patterns in wind-instrument players. J Appl Physiol 1964; *19*: 967-975
5. BOUHUYS A: Physiology and musical instruments. Nature 1969; *221*: 1199-1204
6. BRITISH MEDICAL RESEARCH COUNCIL COMMITTEE ON THE AETIOLOGY OF CHRONIC BRONCHITIS: Standardized questionnaire on chronic respiratory Symptoms. BMJ 1960; *1*: 1665
7. CARROLL LM, SATALOFF RT, HEUER RJ, et al: Respiratory and glottal efficiency measures in normal classically trained singers. J Voice 1996; *10*: 139-145
8. CUGELL DW: Interaction of chest wall and abdominal muscles in wind instrument players. Cleve Clin Q 1986; *53*: 15-20
9. DENIZ O, SAVCI S, TOZKOPARAN E, et al: Reduced pulmonary function in wind instrument players. Arch Med Res 2006; *37*: 506-510
10. EVERS S, ALTENMULLER E, RINGELSTEIN EB: Cerebrovascular ischemic events in wind instrument players. Neurology 2000; *55*: 865-867
11. FIZ JA, AGUILAR J, CARRERAS A, et al: Maximum respiratory pressures in trumpet players. Chest 1993; *104*: 1203-1204
12. GILBERT TB: Breathing difficulties in wind instrument players. Md Med J 1998; *47*: 23-27
13. GODNIC-CVAR J: How to confirm occupational asthma. Int Arch Occup Environ Health 1995; *67*: 79-84
14. GUILLEMAIN P: Some roles of the vocal tract in clarinet breath attacks: natural sounds analysis and model-based synthesis. J Acoust Soc Am 2007; *121*: 2396-2406
15. HAUSFELD JN: Hoarseness – current concepts on etiologies and treatment alternatives. Maryland Med J 1998; *47*: 59-63
16. HERER B: Music and respiratory pathology. Rev Mal Respir 2001; *18*: 115-122
17. KINRA S, OKASHA M: Unsafe sax: cohort study of the impact of too much sax on the mortality of famous jazz musicians. BMJ 1999; *319*: 1612-1613
18. LEVINE HL: Functional disorders of the upper airway associated with playing wind instruments. Cleve Clin Q 1986; *53*: 11-13
19. LUCIA R: Effects of playing a musical wind instrument in asthmatic teenagers. J Asthma 1994; *31*: 375-85
20. MAESTRELLI PJ, BAUR X, BESOT JC, et al: Guidelines for the diagnosis of occupational asthma. Clin Exp Allergy 1992; *22*: 103-8
21. METHFESSEL G: Myofunction in players of wind instruments. Dtsch Zahnarztl Z 1990; *45*: S48-S50
22. NAVRATIL M, REJSEK K: Lung function in wind instrument players and glassblowers. Ann New York Academy Sci 1968; *155*: 276-283
23. PLAMENAC P, NIKULIN AN: Atypia of the bronchial epithelium in wind instrument players and in singers: a cytopathologic study. Acta Cytologica 1969; *13*: 274-278
24. QUANJER PH: Standardized lung function test of the Committee for Coal and Steel. Bull Physiopathol Respir 1983; *19*: 1-95
25. QUANJER PH, TAMELLING GJ, COTES JE, et al: Lung volumes and forced expiratory flows. Report of the Working Party "Standardization of Lung Function Tests". European Community for Coal and Steel. Eur Respir J 1993; *16*: 5-40
26. RUANO-RAVINA A, FIGUEIRAS A, BARROS-DIOS JM: Musicians playing wind instruments and risk of lung cancer: is there an association? Occup Environ Med 2003; *60*: 143-144
27. RAMAZZINI B: Diseases of voice-trainers, singers, and the like. In: *Diseases of Workers*. Translated from "De Morbis Artificium", 1973. New York, London : Hafner Publishing Co, 1964; 329-35
28. SAPIENZA CM, DAVENPORT PW, MARTIN AD: Expiratory muscle training increases pressure support in high school band students. J Voice 2002; *16*: 495-501
29. SAS: SAS/STAT User's Guide, Release 6.05 Edition, Cary, NC/SAS Institute Inc. New York 1988, 1028

30. SAS: SAS/STAT Technical Report p-200, SAS/STAT Institute Inc. New York, 1990, 236
31. SCHORR-LESNICK B: Lung function and health attitudes and habits in professional wind musicians and vocalists. Mount Sinai J Med 1988; *55*: 346-352
32. SCHORR-LESNICK B, TEIRSTEIN AS, BROWN LK, et al: Pulmonary function in singers and wind-instrument players. Chest 1985; *88*: 20l-205
33. SILWKA A, JAROSZ A, NOWOBILSKI R: Music therapy as a part of complex healing. Pol Merkur Lekarski 2006; *21*: 410-405
34. SMITH J, KREISMAN H, COLACONE A, et al: Sensation of inspired volumes and pressures in professional wind instrument players. J Appl Physiol 1990; *68*: 2380-2383
35. WEIKERT M, SCHLOMICHER-THIER J: Laryngeal movements in saxophone playing: video-endoscopic investigations with saxophone players. A pilot study. J Voice 1999; *13*: 265-273
36. WORLD HEALTH ORGANIZATION: Detection of Occupational Lung Disease. Geneva: WHO, 1906: 39-41
37. ZUSKIN E, BUTKOVIC D, SCHACHTER EN, et al: Respiratory function in workers employed in the glassblowing industry. Am J Ind Med 1993; *23*: 835-844