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Relation between the Indicators of Lung Function and the Anthropometric Features of the Chest in Adults

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During prophylactic examinations, the question of whether the anthropometric measurements and the indicators of lung function are interchangeable arises. The purpose of this research was to study the state of the lung function and the correlation between the anthropometric characteristics of the chest and the indicators of lung function in men and women, between 20 and 60 years of age. The subjects were 556 men and women, ethnic Bulgarians, divided into two groups. Some of the subjects were exposed to ammonia and carbon disulfide at their work place. The results of this study confirm our hypothesis about the effects of smoking, obesity, and contact with ammonia. The sex difference in some of the anthropometric indicators, the fluctuating physiometric changes, and the correlation coefficients, as well as the existing difference in the frequency of the disturbances of external breathing are in unison with the model of professional and nonprofessional behavior among men. The complex approach of this study is most successful in revealing the changes in the ventilation function of the lungs, and it makes the evaluation of the involved health risks easier.

Key words: lung function, ventilation capacity, lung volume and flow, anthropometric features.

Introduction

The anthropometric measurements of the chest are a component of the physical development evaluation. There is a correlation between the morphometric characteristics of the chest and the indicators of lung function (ventilation capacity, volume, and flows). Regardless of that, during prophylactic examinations, the question of whether they are interchangeable arises.

The primary purpose of this research was to study the state of the lung function and the correlation between the anthropometric characteristics of the chest and the indicators of lung function in men and women, between 20 and 60 years of age.

Material and Methods

The subjects in this cross-sectional epidemiologic study were 556 men and women, ethnic Bulgarians, divided into two groups, according to age: 20-40 years old and 40-60 years old. Some of the subjects were exposed to proven irritants (ammonia and carbon disulfide) at their work place, while the rest of the subjects did not come in contact with chemical substances.

We measured and calculated the following factors: chest circumference — pause; chest circumference — inspiration; chest circumference — expiration; and average chest circumference; as well as the differences between these. We also studied factors of evaluation of external breathing: inspiratory vital capacity (IVC); forced vital capacity (FVC); forced expiratory volume in one second (FV_1); Tifno Index (FV_1/VC); peak expiratory flow (PEF); forced expiratory flows (FEF_{25}, FEF_{50}, and FEF_{75}); representing respectively 0.25%, 0.50%, and 0.75% of the fluctuation of the forced vital capacity.

We analyzed the individual results of every subject and, according to the registered changes of their external breathing we determined the type of ventilation insufficiency: **restrictive** ventilation insufficiency, **obstructive** ventilation insufficiency, or **mixed** ventilation insufficiency.

The statistical processing (variational and correlational analyses) was performed using a SPSS package. The Student-Fisher's *t*-criterion a level of significance $p<0,05$ was used as correction markers. All the results were statistically systematized at the same level of reliability ($p<0.05$) by means of the "Epi-Info" program for assessment of the relative risk and odds ratio.

Results

Our attempts to establish a correlation between the disturbances in the external breathing of our subjects and their occupations did not yield statistically significant results, neither for men, nor for women. It was found that the frequency of disturbances in the external breathing of obstructive, restrictive, or mixed type and the obstruction of the small respiratory tracts is on average 10%, with an existing gender difference: 3.7% for women and 13.2% for men.

We established statistically significant age-related changes in the anthropometric indicators — chest circumferences at inspiration, expiration, and pause, as well as the average chest circumferences for men and women. The age-related differences for men vary between 29.9 mm and 31.4 mm. These are significantly more pronounced for women, varying between 49.8 mm to 55.0 mm. The differences between the measured chest circumferences, related to the elasticity of the chest wall and the breathing capacity of the lungs, do not significantly change with age. In subjects over 40 years of age two of them decrease, which is more noticeable in women than in men (—5.2 versus —3.3 and —4.8 versus —0.8).

The analysis of the statistical and dynamic ventilation indicators (volume and flow) did not show statistically significant differences in the age subgroups, with the exception of the inspiratory vital capacity (IVC) in men over 40 years old (Table 1 and 2). There is a slightly noticeable linear correlation between the anthropometric and physiometric indicators (Table 3).

By using a single-variable models of risk analysis, we established that smokers have a high risk of external breathing disturbances (OR=3.96 in 95%, CI=1.59 — 10.49). Exposure to ammonia in the work place causes moderate risk of external breathing disturbances (OR=1.68 in 95%, CI=1.00 — 3.00).

Table 1. Basic statistics of anthropometrical and functional characteristics of male

Anthropometric and functional characteristics	Male up to 40 y $n = 179$	Male over 40 y $n = 158$	p
Chest circumference — pause (mm)	969.5 ± 94.5	1000.9 ± 80.2	0.001
Chest circumference — inspiration (mm)	1015.3 ± 90.8	1044.3 ± 76.9	0.05
Chest circumference — expiration (mm)	941.6 ± 94.7	971.7 ± 78.4	0.05
Average chest circumference (mm)	978.3 ± 92.5	1008.1 ± 77.3	0.05
Difference (Chest circ. inspiration — pause) (mm)	45.6 ± 15.2	42.3 ± 14.3	
Difference (Chest circ. pause — expiration) (mm)	27.6 ± 13.1	29.1 ± 14.8	
Difference (Chest circ. inspiration — expiration) (mm)	73.2 ± 19.0	72.4 ± 17.9	
IVC (%)	91.3 ±13.2	96.3 ± 15.5	0.001
FVC (%)	99.2 ± 12.1	97.5 ± 12.6	
FV_1 (%)	94.0 ± 18.8	96.0 ± 17.9	
FV_1 / VC (%)	101.7 ± 21.6	99.7 ± 18.2	
PF (%)	72.7 ± 29.0	71.4 ± 25.1	
MF_{75} (%)	74.9 ± 31.5	73.6 ± 28.1	
MF_{50} (%)	87.1 ± 30.8	91.2 ± 33.6	
MF_{25} (%)	100.5 ± 37.2	101.4 ± 43.3	

Table 2. Basic statistics of anthropometrical and functional characteristics of female

Anthropometric and functional characteristics	Female up to 40 y $n = 45$	Female over 40 y $n = 63$	p
Chest circumference — pause (mm)	823.0 ± 107.1	878.0 ± 80.9	0.05
Chest circumference — inspiration (mm)	860.3 ± 100.7	910.1 ± 76.3	0.05
Chest circumference — expiration (mm)	801.7 ± 104.0	856.3 ± 82.5	0.05
Average chest circumference (mm)	831.0 ± 102.1	883.2 ± 78.9	0.05
Difference (Chest circ. inspiration — pause) (mm)	37.3 ± 15.9	32.1 ± 13.3	
Difference (Chest circ. pause — expiration) (mm)	21.3 ± 10.5	21.7 ± 10.6	
Difference (Chest circ. inspiration — expiration) (mm)	58.6 ± 15.1	53.8 ± 17.3	
IVC (%)	99.1 ± 32.9	93.6 ± 17.0	
FVC (%)	100.3 ± 10.3	99.6 ± 15.6	
FV_1 (%)	95.3 ± 14.3	96.3 ± 18.6	
FV_1 / VC (%)	104.5 ± 23.2	107.4 ± 16.9	
PF (%)	65.9 ± 18.4	69.2 ± 22.6	
MF_{75} (%)	69.0 ± 19.9	71.4 ± 21.3	
MF_{50} (%)	79.6 ± 24.3	80.6 ± 23.0	
MF_{25} (%)	92.1 ± 28.0	86.4 ± 34.8	

Discussion

We found that among the examined subjects, both men and women, there are many external occupational and non-occupational factors, which significantly affect the components of the respiratory system — upper respiratory tracts, lungs, lung circulation of the blood, central nervous system, and chest wall.

The most significant factor is the occupational exposure to ammonia and carbon disulfide — industrial poisons with a proven irritating effect.

A high concentration of ammonia has been proven to be a serious health hazard. Ammonia was one of the first extremely hazardous substances (EHS's) to be addressed by NAC (National Advisory Committee) AEGL (acute exposure guideline levels), and is of great concern both to companies and communities.

Ammonia in concentration levels above 3500mg/m^3 results in immediate death, caused by seizures, inflammation, and oedema of the larynx [5]. The clinical picture of acute ammonia poisoning is characterized by the "curare" effect of ammonia and the sharp disturbances of the breathing and blood circulation. Post mortem, there are signs of chemical burns to the eyes and the upper respiratory tracts [13].

High concentrations of ammonia cause heavy eye lacrimation and pain, accompanied by a sharp decrease of the lung ventilation and acute emphysema [13, 4]. Most frequently described, clinically insignificant, reversible toxic effects of ammonia harm the eyes and the upper respiratory tracts. There are noticeable irritation of the eyes, lacrimation, and changes in breathing [12]. CS_2 has an even more pronounced irritating effect on the skin and the mucous membranes, causing second and third degree burns at contact with the skin [13]. Decreased vital volume and dyspnoea can be observed after exposure to CS_2 in its gas state [10, 3]. Vanhoorne et al. (1995) have produced reliable evidence of pain that is more frequent, burning, and photophobia after exposure to CS_2. It is accepted that CS_2 is primarily a neurotropic poison [1, 2, 8, 7].

The effect that ammonia and carbon disulfide have on the CNS disturbs the muscle activity of the chest wall, which could lead to disturbances in external breathing.

After analyzing the registered individual dynamic and static ventilation indicators, our results show that 10% of the studied subjects, on average, experience ventilation insufficiency, with a noticeable difference in the frequency between males and females. Much more frequently, ventilation insufficiency is experienced by men, who represent half of the machine operators and most of the maintenance staff, often working with high concentrations of ammonia and carbon disulfide.

Table 3. Correlation coefficients of selected functional variables with some anthropometrical featues

Variables	Male	Female
IVC / Difference (Chest circ. inspiration — pause)	0.182	0.252
IVC / Difference (Chest circ. inspiration — expiration)	0.213	0.251
FVC / Difference (Chest circ. inspiration — pause)	0.247	0.204
FVC / Difference (Chest circ. pause - expiration)	0.118	0.247
FVC / Difference (Chest circ. inspiration — expiration)	0.291	0.337
FV_1 / ГО Difference (Chest circ. inspiration — expiration)		0.196
FV_1/VC / Difference (Chest circ. inspiration — expiration)	- 0.112	

The muscles of the chest wall function as a "pump" of the respiratory system. The accumulation of subcutaneous fatty tissue (SFT) of the torso increases the thickness of the chest wall and impedes the proper functioning of this "pump." We found a statistically significant increase of the chest circumference at rest, without changes in the indicators of the ventilation function of the lungs during inhaling and exhaling. The statistically significant difference in the vital capacity of men of or above 40 years of age is within the physiological fluctuations of the method ($\pm$ 20%). We are willing to accept that the increase in the anthropometric indicators is due to the accumulation of fatty tissue on chest cell wall. In previous studies, we have established significant difference in the quantity and location of SFT in women and men [14]. Obesity among the studied subjects, in combination with the chemical factor could disturb the normal connection and coordination between the regulator (CNS) and the "pump", changing the functioning of the respiratory system.

Smoking also affects the condition of the respiratory function, which is a harmful habit for 70% of the studied population. According to data by Roy [6], there is statistically reliable evidence that the indicators for evaluation of external breathing (FVC, FEV_1, $FEV_{0.7}$, and FEV%) are lower in men and women who smoke than in non-smokers. Our results completely support the role of smoking as one of the most significant risk factors for the observed disturbances of the ventilation function. The high risk of disturbances of the external breathing in smokers with OR = 3.96 with 95% CI = 1.59 — 10.49, realistically reflects the results of the combined effect of irritating gases, the increasing size of the wall cell caused by fatty tissue under the skin, and smoking for majority of the studied subjects. In support of this claim are the low correlation coefficients between the anthropometric and physiometric indicators, which we found both in men and in women (Table 3).

Conclusions

The results of this study confirm our working hypothesis about the effects of smoking, obesity, and contact with ammonia. The sex difference in some of the anthropometric indicators, the fluctuating physiometric changes, and the correlation coefficients, as well as the existing difference in the frequency of the disturbances of external breathing are in unison with the model of professional and nonprofessional behavior among men. The complex approach of this study is most successful in revealing the changes in the ventilation function of the lungs, and it makes the evaluation of the involved health risks easier.

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