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A FUNCTIONAL APPROACH TO INTERPRETING SPIROMETRY TO FEMALE STUDENTS FROM OTHER FACULTIES OF THE UNIVERSITY OF ORADEA

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Abstract: Background & objectives: Pulmonary function tests have evolved as clinical tools in diagnosing and management of respiratory diseases as they provide objective information about the status of an individual's respiratory system. The assessment of patients and program outcomes is the crucial element of a PR program. This study was aimed to evaluate pulmonary function by spirometry and to interpret in terms of functional way. Methods: To determine the pulmonary health of young people, we evaluated 50 female students from different faculties of the University of Oradea with no history in professional sports. The pulmonary functions were recorded on a computerized spirometer (Vitalograph ALPHA brand model # 6000); the parameters measured were: VC, FVC, FEV_1, FEV_1%VC, FEV_6, PEF, FEF 25, FEF 50, FEF 25/75 and MMVind Interpretation & conclusions: From the present investigation it can be concluded that the students present all types of presumptive clinical diagnosis (normal, obstructive, restrictive and mixed deficit) with different degrees of severity. From a functional point of view, it can be said that students develop bad *breathing* habits – or simply *don't know* how to *breathe properly*

Key words: pulmonary function, lung volumes, Spirometric values, young adulthood

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INTRODUCTION

The history of Pulmonary Rehabilitation (PR) dates back over decades and certain PR elements over centuries. The evidence of PR's effectiveness has considerably strengthened and

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increased over the past forty years. During this time, the role and impact of PR has been firmly established and is now considered a key component in management of chronic respiratory disease (Garvey et al., 2013).

Also, Pulmonary Rehabilitation can help to gain strength, reduce symptoms of anxiety or depression, and makes it easier to manage routine activities, work and outings or social activities.

The literature on pulmonary rehabilitation has increased substantially and provided justification for including pulmonary rehabilitation in practice guidelines for primary and secondary care. The crucial element of a PR program is the assessment of patients and program outcomes (Peno-Green et al., 2009).

The clinical reasoning process in cardiorespiratory physiotherapy begins with the collection of both subjective and objective data (Holdar et al, 2013). The data collected shall then be explained and interpreted. An important step in clinical judgment is spirometry, a powerful tool that can be used to detect, follow, and manage patients with lung disorder.

How Crapo R.O. (1994) specifies, the pulmonary-function tests are useful in diagnosing and managing pulmonary diseases. It can identify abnormalities of lung function that might otherwise be overlooked and can exclude the possibility of some respiratory disorders such as chronic obstructive pulmonary disease.

Smith et al., (2010) have used FEV_1, FVC and FEV_1/FVC to determine the effect of changing guidelines during a longitudinal study of young adults.

Rochat et al., (2013) developed spirometry reference equations for a central European population between 8 and 90 years of age that can be implemented in a wide range of clinical settings. The largest forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) were selected. All other parameters [FEV1/FVC ratio, peak expiratory flow (PEF), mean expiratory flow at 75%, 50%, 25% of expired volume ($MEF_{75, 50, 25}$)] were taken from the trial with the largest sum of FVC and FEV1.

For spirometry, many parameters can be calculated but most do not add clinical utility and should not be routinely reported. Only FVC, FEV1, and FEV1/FVC need be routinely reported. Measurement of slow VC and calculation of FEV1/VC are a useful adjunct in patients with suspected airflow obstruction. Reporting FEV1/FVC (or FEV1/VC) as a decimal fraction, and not reporting it as a percentage of the predicted value for this ratio, will help to minimize miscommunication (Culver et al., 2017)

MATERIAL AND METHODS

Subjects:

This study was conducted in the University of Oradea, Athletics Hall, in bodybuilding room.

To determine the pulmonary health of young people, we evaluated 50 female students from different faculties of the University of Oradea with no history in professional sports. The mean age and body height were 20.42±1.83 yrs., respectively 164.55 ±5.43cm. Students were enrolled in sports such as handball, basketball, volleyball, aerobics and fitness. Subjects with history of pulmonary diseases were excluded from the study. The experimental protocol was explained to all.

***Determination of pulmonary function measurements*:**

The pulmonary functions were recorded on a computerized spirometer (Vitalograph ALPHA brand model # 6000), The parameters measured were: VC (vital capacity), FVC (forced vital capacity), FEV_1 (forced expiratory volume in 1 sec), FEV_1%VC (ratio to FEV_1 to vital capacity expressed as a percentage), FEV_6 (forced expiratory volume in six seconds), PEF (Peak expiratory flow), FEF 25, FEF 50, FEF 25/75 (maximal (mid-) expiratory flow at 25%, 50 %, 25%-75% of the forced vital capacity), MMVind (Maximal voluntary ventilation). All the measurements were conducted in standing posture with nose clipped. For each volunteer three satisfactory efforts were recorded.

RESULTS & DISCUTIONS

When personal data has been collected each subject was asked if they are smokers, non-smokers or ex-smokers. The results were 24% smokers, 68% non-smokers and 8% ex-smokers.

Holmen et al., (2002) from Norway, shows a survey conducted in 1995-1997 in which a total of 6811 students (aged 13-18 yrs. without asthma), 1.342 (20%) reported current smoking, 2.993 (44%) reported never-smoking, 2.476 (36%) occasional smokers. Daily number of smokers increased with age and was more pronounced to females.

Compared to Romania where, proportion of daily smokers of cigarettes, persons aged 15 and over are 20.5%; 32.7% men and 9.1% women, in Norway this proportion is 12.5%; 12.7 men and 12.3 women (Eurostat. Statistic explained, 2015).

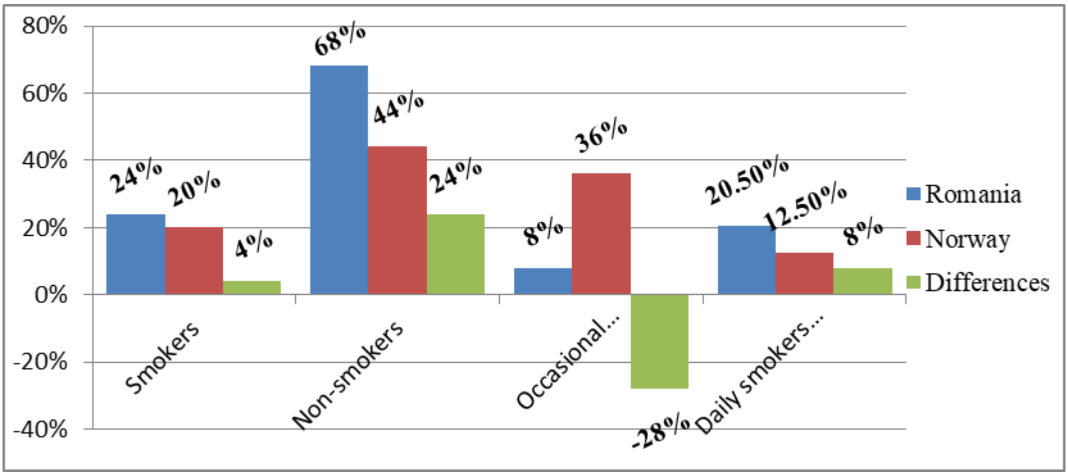

Figure 1. Tobacco consumption

It can be seen that the proportion of daily smokers in Romanian population is higher by 8% compared to Norway.

To the comparison between research studies, we have more smokers by 4%, but the positive thing is much bigger difference to non-smokers. We have 24% more non-smokers in the group of students.

Spirometry was carried out in accordance with the current standardization recommendations of the ATS-ERS (Miller et al., 2005)

The results obtained from lung function tests have no meaning unless they are compared with reference values or predicted values.

After the VC (vital capacity) and dynamic pulmonary functions were recorded for all students, the database for subsequent interpretations has been structured.

Vital Capacity (VC) is the largest of the volumes from either a forced (FVC) or a slow (SVC) maneuver. There is little or no difference between VC and FVC (VC-FVC) in normal subjects (Chhabra, 1998).

The subjects in our study do not have history of lung disease; this also comes from the similar average values between VC 60.46±28.98 and FVC 61.98% ±28.06

An algorithm for interpreting spirometry results is given by: Barreiro and Perillo, 2004; Miller and Enright, 2012; Johnson and Theurer, 2014.

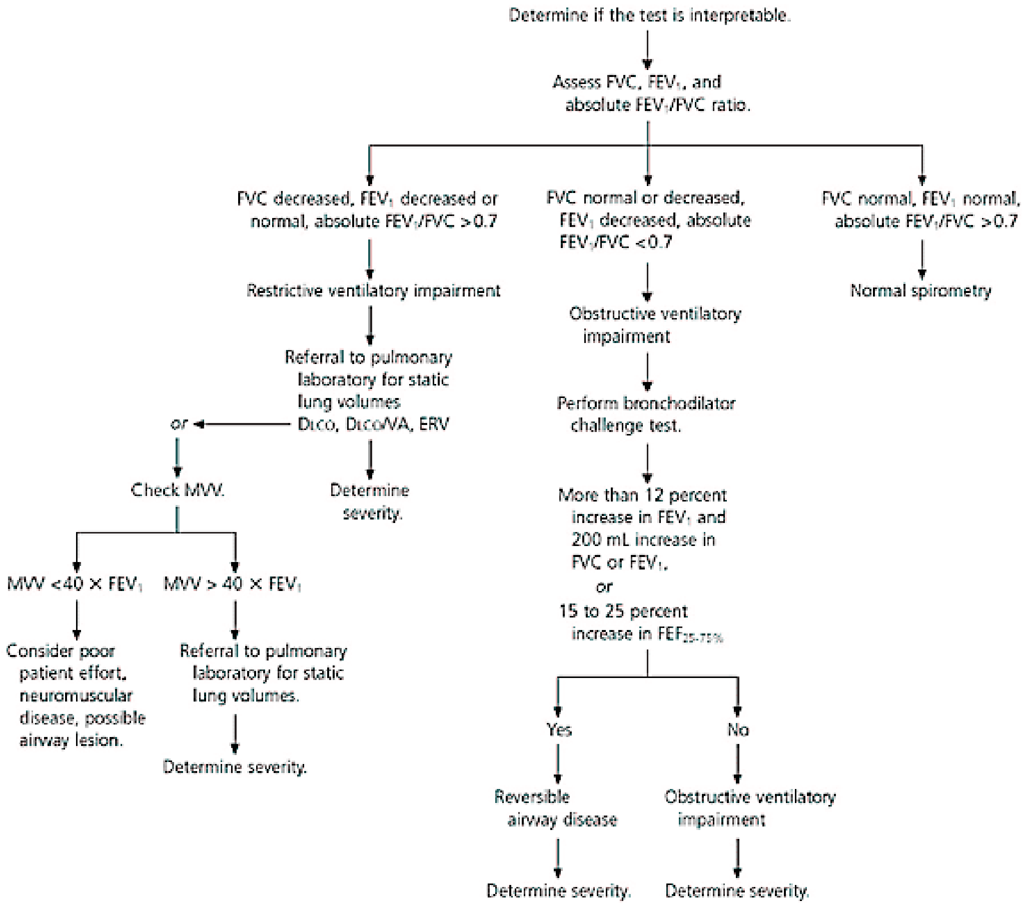

Figure 2. Interpreting Spirometry Results (Barreiro and Perillo, 2004)

For the severity levels of Obstruction/Restriction we have taken into account the patterns disease based on adult ATS/ERS recommendation.

FVC (FEV_6)&FEV_1, % predicted: Normal ≥ 80%; Mild 70-80%; Moderate 60-69%; Moderately severe 50-59%; Severe 35-49%; Very severe <35%

FEV_1/FVC, % predicted: Normal ≥ 70%: Mild 60-69%; Moderate 50-59%; Severe < 50%

We also considered how to define the lower limit of the normal range, presented by Culver (2012).

By applying the algorithm for interpretation of spirometry, as well as the severity of the dysfunctions, we have obtained a presumptive clinical diagnosis.

Table 1. FVC, FEV1, FEV1r parameter extracted from the database

Nr. Crt.	p FVC (litre)	r FVC (litre)	**% FVC**	p FEV1 (litre/sec)	r FEV1 (litre/sec)	**% FEV 1**	p FEV1R (litre/sec)	r FEV1R (litre/sec)	**% FEV1R**
1	3.38	3.71	**110**	2.94	2.98	**101**	0.84	0.80	**95**
2	3.33	3.47	**104**	2.90	2.90	**100**	0.84	0.84	**100**
3	3.73	3.90	**105**	3.25	1.67	**51**	0.84	0.43	**51**
4	3.68	3.66	**99**	3.21	2.57	**80**	0.84	0.70	**83**
5	3.64	3.84	**105**	3.17	2.89	**91**	0.84	0.75	**89**
6	3.99	4.37	**110**	3.49	2.50	**72**	0.84	0.57	**68**

7	4.08	3.91	**96**	3.57	3.23	**90**	0.84	0.83	**99**
8	3.90	3.96	**102**	3.41	2.95	**87**	0.84	0.74	**88**
9	3.64	3.45	**95**	3.17	1.64	**52**	0.84	0.48	**57**
10	3.64	2.91	**80**	3.17	2.39	**75**	0.84	0.82	**98**
11	3.64	2.84	**78**	3.17	2.16	**68**	0.84	0.76	**90**
12	3.77	3.61	**96**	3.29	2.58	**78**	0.84	0.71	**85**
13	3.68	2.99	**81**	3.21	2.30	**72**	0.84	0.77	**92**
14	3.73	3.78	**101**	3.25	2.49	**77**	0.84	0.66	**79**
15	3.68	3.05	**83**	3.21	2.37	**74**	0.84	0.78	**93**
16	3.42	2.71	**79**	2.98	1.97	**66**	0.84	0.73	**87**
17	3.86	2.72	**70**	3.37	2.16	**64**	0.84	0.79	**94**
18	3.86	3.09	**80**	3.37	2.23	**66**	0.84	0.72	**86**
19	3.59	2.61	**73**	3.13	1.58	**50**	0.84	0.61	**73**
20	3.99	3.10	**78**	3.49	1.87	**54**	0.84	0.60	**71**
21	3.95	2.00	**51**	3.45	1.39	**40**	0.84	0.70	**83**
22	3.59	1.57	**44**	3.13	1.14	**36**	0.84	0.73	**87**
23	3.77	2.04	**54**	3.29	1.60	**49**	0.84	0.78	**93**
24	3.37	1.90	**56**	2.94	1.44	**49**	0.84	0.76	**90**
25	3.37	1.64	**49**	2.94	1.48	**50**	0.84	0.90	**107**
26	3.90	1.55	**40**	3.41	1.50	**44**	0.84	0.97	**115**
27	3.90	1.64	**42**	3.41	1.48	**43**	0.84	0.90	**107**
28	3.99	2.24	**56**	3.49	1.34	**38**	0.84	0.60	**71**
29	3.99	1.77	**44**	3.49	1.43	**41**	0.84	0.81	**96**
30	3.77	1.91	**51**	3.29	1.55	**47**	0.84	0.81	**96**
31	3.77	1.81	**48**	3.29	1.38	**42**	0.84	0.76	**90**
32	3.99	1.53	**38**	3.49	1.06	**30**	0.84	0.69	**82**
33	4.26	1.21	**28**	3.73	1.12	**30**	0.84	0.93	**111**
34	3.90	1.79	**46**	3.41	1.18	**35**	0.84	0.66	**79**
35	3.55	1.52	**43**	3.10	1.08	**35**	0.84	0.71	**85**
36	3.55	1.22	**34**	3.10	0.63	**20**	0.84	0.52	**62**
37	3.55	1.02	**29**	3.10	0.78	**25**	0.84	0.76	**90**
38	3.64	1.02	**28**	3.17	0.76	**24**	0.84	0.75	**89**
39	3.77	0.95	**25**	3.29	0.88	**27**	0.84	0.93	**111**
40	3.81	1.02	**27**	3.33	0.82	**25**	0.84	0.80	**95**
41	3.95	1.14	**29**	3.45	0.82	**24**	0.84	0.72	**66**
42	3.37	0.92	**27**	2.94	0.60	**20**	0.84	0.65	**77**
43	3.68	1.36	**37**	3.21	0.90	**28**	0.84	0.66	**79**
44	4.17	1.47	**35**	3.65	0.77	**21**	0.84	0.52	**62**
45	4.17	1.58	**38**	3.65	0.82	**22**	0.84	0.52	**62**
46	3.99	1.77	**44**	3.49	0.65	**19**	0.84	0.37	**44**
47	3.96	1.10	**28**	3.37	0.89	**26**	0.84	0.81	**96**
48	3.46	0.57	**16**	3.02	0.40	**13**	0.84	0.70	**83**
49	3.87	3.08	**78**	3.31	2.22	**65**	0.82	0.71	**85**
50	3.98	4.35	**109**	3.48	2.49	**71**	0.83	0.57	**67**
M	***3.76***	***2.32***	***61.98***	***3.28***	***1.64***	***50.14***	***0.84***	***0.72***	***84.76***
S	***0.22***	***1.05***	***28.06***	***0.19***	***0.73***	***22.71***	***0.003***	***0.127***	***15.37***

FVC=Forced vital capacity; FEV1=Forced expiratory volume - one second; FEV1r=FEV1/FVC ratio (FEV1%) =Tiffeneau-Pinelli index (reactivity index/bronchial permeability); n= predicted values; r= best results obtained; $M = \sum X / N$; S = standard deviation of the sample

In Table 1: FVC, FEV1, FEV1r represent the Spirometry reference values for presumptive clinical diagnosis (Culver et al., 2017).

On the basis of the averages of the reference values obtained by the students, in accordance with table 1, it should be noted that presumptive clinical diagnosis is Restrictive ventilatory impairment: FVC 61.98% ± 28.06, FEV1 50.14 ± 22.71 and FEV1r 84.76 ± 15.37; severity level - Moderate restriction of extra parenchymal cause with combined dysfunction (inspiratory and expiratory), moderately severe obstruction

Individual interpretation of spirometry reference values shows that the students group has all three types of ventilation dysfunctions

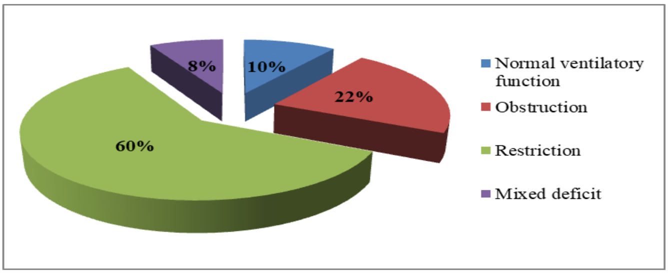

Figure 3. Presumptive clinical diagnosis according to the reference values of spirometry

Figure 3 shows that in presumptive clinical diagnosis dominate Restrictive ventilatory impairment - 60% followed by Normal ventilatory function – 24%, Obstructive ventilatory impairment – 8%, and Mixed deficit – 8%.

Causes of Restrictive lung diseases may be intrinsic or extrinsic to the lung parenchyma. Examples of extrinsic causes are respiratory muscles weakness, chest deformities, or other cardiorespiratory diseases (cardiomegaly, hemothorax, pneumothorax, empyema, pleural effusion or thickening).

Students have no history of lung disease, so the restriction is likely to be of the extra parenchymal cause with combined dysfunction (inspiratory and expiratory)

It shall be specified that values below lower limit of normality (LLN) (PEF and FEF especially $FEF_{25/75}$) are present in all Normal ventilator functions (24%).

The interpretation of values near the LLN is uncertain due to overlapping values between normal low values and those reflecting early disease (Culver, 2012)

In terms of severity level: Restriction is 20% Mild; 20% Moderately Severe; 33.3% Severe; 26.6% Very Severe, Obstruction: 50% Mild and 50% Moderately Severe and Mixed deficit: 25% Very Severe Restriction, Very severe obstruction and 75% Severe restriction and Very severe obstruction.

Before proceeding with a possible functional interpretation of these results, it was necessary to also take into account the other spirometry values.

The FEV_6 - Forced Expiratory Volume after 6 seconds indicates the amount of air exhaled with maximum effort in the first six seconds. This parameter is primarily used to ensure expiratory efforts meet or exceed 6 seconds.

In 2000 Swanney et al., said that “the reproducibility of FEV6 was superior to that of FVC … FEV6 is an accurate, reliable alternative to FVC for diagnosing airway obstruction and that FEV6 is reasonably comparable to FVC for the spirometric diagnosis of restriction. FEV6 is more reproducible and less physically demanding for patients.”

When comparing the two averages obtained with the spirometry values, it can be observed that FEV6 67.26±28.32 is greater than FVC 61.98% ± 28.06.

However, this does not influence the clinical diagnosis or severity of diseases. It can be specified, however, that the Moderate severity level is within the range of 60 to 69%. FEV6 values are found to the upper limit, while FVC to the lower limit

DeVrieze and Bhimji (2018) explain the Peak expiratory flow rate (PEFR) as being the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. PEFR primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the patient. For ease of patient interpretation, the colors of a traditional traffic light have been used to designate varying degrees of peak flow limitation (Green, Yellow and Red Zone). Green Zone: ≥ 80%; your asthma is under reasonably good control. Continue your prescribed program of management; Yellow Zone: 50%-80%; Indicates caution. It is time for decisions. Your airways are narrowing and may require extra treatment. Your symptoms can get better or worse depending on what you do, or how and when you use your prescribed medication. You and your healthcare provider should have a plan for yellow zone readings; Red Zone: ≤ 50%; Indicates a medical emergency. Immediate decisions and actions need to be taken. Severe airway narrowing may be occurring. Take your rescue medications right away. Contact your healthcare provider now and follow the plan they have given you for red zone readings.

These should correlate with a written asthma action plan.

The interpretation of PEF results shows that students are at 88% in the Red Zone (indicates a medical emergency) and 12% in the Yellow Zone (indicates caution).

The average obtained is 30.22±13.77which is directed toward the Red Zone. But, from a functional, qualitative point of view, this mark can be interpreted as a low effort by the subjects and also the most likely, low resistance of the expiratory muscles

FEF_{25}, FEF_{50}, FEF_{75} is the Forced Expiratory Flow at 25%, 50%, 75% of FVC and represent the flow rate at the 25%, 50%, 75% point of the total volume (FVC) exhaled. These expiratory flows do not contribute usefully to clinical decision making.

The mid-expiratory flow rate ($FEF_{25–75\%}$) is the average forced expiratory flow rate over the middle 50 percent of the FVC. It can help in the diagnosis of an obstructive ventilator pattern. Because it is dependent on FVC, the $FEF_{25–75\%}$ is highly variable. In the correct clinical situation, a reduction in $FEF_{25–75\%}$ of less than 60 percent of that predicted and an FEV_1/FVC ratio in the low to normal range may confirm airway obstruction (Barreiro and Perillo, 2004)

In our assessments, only 10% of $FEF_{25–75\%}$ cases have values higher than 60% of prediction. The group average recorded low values 36.22±17.73. Only in 16 % of cases is the airway obstruction confirmed, in the other, less than 60% the value reduction is accompanied by FEV1/FVC ratio increased.

The maximal voluntary ventilation (MVV) maneuver is another test that can be used to confirm obstructive and restrictive conditions. The result is extrapolated to 60 seconds and reported in liters per minute. MVV generally is approximately equal to the FEV_1×40 (Barreiro and Perillo, 2004). Evans et al., (2008) and Gold and Koth, (2016), believe that the decrease of MVV depends on poor patient effort, loss of coordination of respiratory muscles, musculoskeletal disease of the chest wall, neurologic disease, and deconditioning from any chronic illness, as well as ventilator defects.

An average of 50.56±23.68 for the MVV assessment (normal ≥0.80) indicates that the MVV is low relative to the FEV1 and suggests poor effort or disease. Most likely it can be interpreted as poor effort more than diseases, because rapid, shallow breathing can compensate effectively for the decreased lung volume

After interpretation of the Spirometry variables, mechanical abnormalities in the respiratory system can be observed. Figure 3 shows that all types of presumptive clinical diagnosis with different degrees of severity are encountered in the evaluation of the student group. Whether FVC, FEV1, FEV1r represent the reference values, we have taken into account the interpretation of all the spirometry variable for presumptive clinical diagnosis

According to the study published by Lutfi (2017) updating the physiological basis, clinical significance and interpretive approaches to lung volume measurements, a functional approach to spirometry values can be established.

Decreased VC/FVC - Functional meaning:

- decreased/reduced thoracic cage expansion;
- decreased/reduced compliance of the lungs;
- decreased/reduced for both, chest wall expansion and compliance of the lungs;
- so, impossibility to increase the ventilation per minute (to physical effort) which can only by frequency (rapid shallow breathing) can still cope with the demands; this greatly increases the respiratory travail

Decreased FEV_1- Functional meaning:

- decreased/reduced the contraction force of the breathing muscles, especially the forced exhaling muscles;
- decreased/reduced the “springy-ness” or elasticity of parenchyma (decrease the elastic recoil) [emphysema - the lung tissue involved in exchange of gases (oxygen and carbon dioxide) is impaired or destroyed];
- increased the resistance to air flow opposite to peripheral segmentation on airways (chronic bronchitis and asthma)

FEV1r=FEV1/FVCratio (FEV1%) = Tiffeneau-Pinelli index (reactivity index/bronchial permeability) it depends on the strength of the breathing muscles.

- if the force of the breathing muscles is very low, the ability to perform a forced exhale is reduced and the FEV1/FVC ratio will be below the predicted value;
- if the force of the respiratory muscles is preserved, but the thoracic wall is abnormally rigid so that the expiratory position of rest cannot be reached, FEV1/FVC ratio may be normal or increased.

During the clinical reasoning, the therapist analyzes multiple variables contributing to the patient’s limited physical capacity and performance. The process is vital, first of all, to make the difference between normal and pathological, and in the case of pathology orientation, the severity level of the pathology should be properly analyzed.

CONCLUSIONS

Within the group of students were 24% smokers, 68% non-smokers and 8% ex-smokers

Evaluation of pulmonary function by use of spirometry revealed all types of presumptive clinical diagnosis with different degrees of severity: 60% - Restrictive ventilatory impairment of the extra parenchymal cause with combined dysfunction (inspiratory and expiratory); 24% - Normal ventilatory function; 8% - Obstructive ventilatory impairment; 8% - Mixed deficit

Following a functional approach, it can be considered:

- decreased compliance of the lungs, chest wall or both;
- thoracic wall is abnormally stiff so that the expiratory position of rest cannot be reached;
- low resistance of the expiratory muscles;
- decreased the contraction force of the breathing muscles, especially the forced exhaling muscles;
- poor effort, because rapid, shallow breathing can compensate effectively for the decreased lung volume.

Depending on the deterioration level of the Spirometry values, from the lowest to the least affected, the physiotherapy approach algorithm will be structured taking into account physiological implication.

Although spirometry is a valuable tool, it must be taken in the context of the clinical and functional presentation of the individual being assessed

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