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Effect of Closed Building Syndrome on Pulmonary Function

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Abstract

Background: Closed building syndrome affects pulmonary function.

Aim of Study: This study aimed to identify the effect of closed building syndrome on pulmonary function.

Subjects and Methods: Eighty switch workers men with closed building syndrome were included in this study. Their age ranged from thirty to forty years old. They were recruited from from El-Kasr El-Ainy University Hospital. Before inclusion in this study full description of study, procedures for each patient and written consent had been signed. All men patients were evaluated with ventilatory function testing and arterial blood gases.

Results: The mean values of age (year), weight (kg), height (cm), and BMI (kg/m^2) were 34.34±3.11, 74.02±8.00, 168.67±5.96, and 26.02±1.90, respectively in study group. Number (percentage) of normal and abnormal (hypoxic) arterial blood gases distributions were 77 (96.3%) and 3 (3. 8%), respectively. Number (percentage) of normal, obstructive and restrictive R. functions distributions were 54 (67.5%), 11 (13.7%), and 15 (18.8%), respectively. The mean value of total working was 83.91±14.75 hours with minimum and maximum values 6720.00 hour and 26880.00 hour, respectively. The mean value of respiratory functions was 87.09± 14.38% with minimum and maximum values 60.20% and 103.3%, respectively. There was strong negative correlation between total working time and respiratory functions (r=–0.68; p =0.0001; p<0.05). There was strong negative correlation between total working time and respiratory functions. The results showed that there was significant relation between working time and respiratory functions also, this means that change in the respiratory functions are consistent with change in total working time.

Conclusion: There were significant relation between working time and respiratory functions.

Key Words: *Closed building syndrome – Pulmonary functions – Pulmonary function testing – Arterial bloodgases.*

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Introduction

THE term "Closed Building Syndrome" (CBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone or may be widespread throughout the building **[1]**.

Closed building syndrome consists of a group of mucosal, skin, and general symptoms that are temporally related to residential and office buildings. CBS comprises a group of symptoms of unclear causes divided into mucous membrane symptoms related to the eyes, nose, throat, and dry skin, together with what are often called general symptoms of headache and lethargy **[2]**.

Closed building syndrome can be influenced by a variety of factors, like building-related factors (air-conditioned building, fresh air ventilation rates, indoor temperature, poor building service maintenance and cleaning, relative humidity **[3]**.

Pulmonary Function Tests (PFTs) include tests that measure lung size and air flow, such as spirometry and lung volume tests. Other tests measure how well gases such as oxygen get in and out of your blood. These tests include pulse oximetry and arterial blood gas tests. Another pulmonary function test, called fractional exhaled nitric oxide, measures nitric oxide, which is a marker for inflammation in the lungs **[4]**.

Spirometry is one of a number of tests to evaluate respiratory function. The basic spirometric procedure involves the measurement of gas volume and rate of airflow during a maximal, forced expiration. The mechanical properties of the airways, lung, pleura, chest wall and respiratory muscles all contribute to these results [5].

Arterial Blood Gas (ABG) analysis is an essential part of diagnosing and managing a patient's oxygenation status and acid-base balance. The usefulness of this diagnostic tool is dependent on being able to correctly interpret the results [6].

Subjects and Methods

I- Subject:

Eighty switch workers men with closed building syndrome were included in this study. Their age ranged from 30-40 years old. They were recruited from from El-Kasr El-Ainy University Hospital. They signed a consent form. The study started in February 2019 and ended in June 2020.

Ethical considerations:

Before the initiation of the study a consent form was obtained from each subject as an agreement to be included in the present study. Each subject received detailed explanation of procedures of the measurement devices and the purpose of the study was explained for each subject.

Inclusion criteria:

Subject included in the study subject included in the study had the following criteria: Eighty switch office workers from El-Kasr El-Ainy University Hospital. Their working time ranged from 6-8 hours daily. They had symptoms of CBS for more than 5 years. Their age ranged from 30-40 years old. Their BMI ranged from 20 to 30kg/m^2.

Exclusion criteria:

Subject were excluded from the study had the following conditions or diseases: Unstable cardiovascular problems. Chest disease. Smokers. Peripheral vascular diseases.

II- Methods:

All men were evaluated with ventilatory function testing and arterial blood gases.

1- *Evaluation equipment:*

1- Standard weight scale: It was used to measure weight and height to calculate Body Mass Index (BMI) for each participant.

2- MIR Spiro-lab Spirometer: It was used to measure ventilator functions (FEV_1, FEV_1/FVC and FEF 25-75%).

3- Laboratory GEM premier 3000: It was used to measure Arterial blood gases (pH, PaO_2, SaO_2, $PaCO_2$ and HCO_3).

2- *Procedures:*

History was carefully taken to collect data about his general condition, physical activity and current medication. The procedures of this study were divided in the following main parts:

1- *Preparatory procedures:*

A- All medical and demographic data of subjects were collected.

B- Vital signs were measured to ensure that all subjects were medically stable.

2- *Evaluation procedures:*

• *Weight and height measurements:* Weight and height were measured while the man wearing a thin layer of clothes to calculate the BMI before participating in the study according to the following equation:

$$\text{Body mass index (BMI)} = \frac{\text{Weight (Kg)}}{\text{Height (m}^2\text{)}}$$

• *Pulmonary function testing:*

A- *Ventilatory function testing:*

1- Repeat the purpose of the examination and emphasize the need for extra effort from the participant to get maximal results.

2- Ask the participant to loosen any tight clothing and to remove dentures if they are not secure.

3- Install the cardboard mouthpiece in the filter using the plastic wrap. Make certain that the cardboard mouthpiece is inserted into the filter firmly, to avoid air leaks in the system.

4- Spirometry testing should be performed in the standing position, unless the sample person is physically unable to do so.

5- Have participant elevate the chin and extend the neck slightly. This is important because if the chin is down, it creates a partial airway obstruction.

6- Have the participant place a nose clip on his or her nose. The nose clip should be removed between trials.

7- Demonstrate a trial exhalation using your own mouthpiece. The following coaching instructions may be helpful: “Take a big deep breath and fill your lungs with air”.

8- When ready to initiate the test, click OK to the “ Start Test?” then instruct the participant to take a deep breath, insert the mouthpiece, and BLAST the air out.

9- As soon as the messages “6-seconds of exhalation” and “Plateau Achieved” appear, instruct the participant to stop and remove the mouthpiece from the mouth.

10- The test results screen is displayed after each completed FVC maneuver.

B- *Arterial blood gas (ABG) analysis:*

1- The assessment was carried out at Kasr El-Aini, Laboratory of Biochemistry Department.

2- Arterial blood samples (3ml) from the radial artery were collected with a thin needle from each participant.

3- The samples were introduced to Laboratory GEM premier 3000 device for obtaining results.

3- *Statistical procedures:*

The statistical analysis was conducted by using statistical SPSS Package program version 20 for Windows (SPSS, Inc., Chicago, IL). The following statistical procedures were conducted:

- Numerical data descriptive statistics including the mean and standard deviation for demographic data (age, weight, height, BMI) and working time in study group.
- Categorical data descriptive statistics including the number and percentage for Basal Metabolic Index (BMI), arterial blood gases (saO_2), and R. functions in study group.
- Chi-square test to compare the distribution within each categorical variable in study group.
- Pearson correlation coefficient to determine the strength and direction of a linear relationship between working time and R. functions in study group.
- Significant level: All statistical analyses were significant at 0.05 level of probability ($p \leq 0.05$).

Statistical analysis:

The statistical analysis was conducted by using statistical SPSS Package program version 25 for Windows (SPSS, Inc., Chicago, IL). Quantitative variables data are expressed as mean and standard deviation for demographic data and total working time. Qualitative variables data are expressed as number and percentage for BMI, arterial blood gases, and R. functions. Chi-square test used to compare the distribution within each qualitative variable in study group. Spearman rank correlation coefficient used to determine the strength and direction of a linear relationship between working time and R. functions in study group. All statistical analyses were significant at level of probability less than or equal 0.05 ($p \leq 0.05$).

Results

A total of 80 patients participated in this study, the mean values of age (year), weight (kg), height (cm), BMI (kg/m^2), working time (hours) were 34. 34±3.11year, 74.02±8.00kg, 168.67±5.96cm, 26. 02±1.90kg/m^2, and 34.34±3.11 hour, respectively in study group (Table 1).

Table (1): Mean values and range of demographic data in study group.

Variables	Mean ± SD (n=80)	Range
Age (Year)	34.34±3.11	(30.00-40.00)
Weight (kg)	74.02±8.00	(55.00-96.00)
Height (cm)	168.67±5.96	(155.00-180.00)
BMI (kg/m^2)	26.02±1.90	(20.10-29.60)
Total working (hours)	34.34±3.11	(6720.00-26880.00)

Data are expressed as mean ± Standard Deviation (SD).

Number (percentage) of normal and overweight BMI distributions were 19 (23.8%) and 61 (76.3%), respectively (Table 2). Number (percentage) of normal and abnormal (hypoxic) arterial blood gases distributions were 77 (96.3%) and 3 (3.8%), respectively (Table 2). Number (percentage) of normal, obstructive, and restrictive R. functions distributions were 54 (67.5%), 11 (13.7%), and 15 (18.8%), respectively (Table 2). Number (percentage) of normal, mild, moderate, and sever R. functions distributions were 54 (67.5%), 18 (22.5%), 7 (8.8%), and 1 (1.3%), respectively (Table 2). The statistical analysis revealed that there was significantly difference (p=0.000 1; $p<0.05$) in BMI, arterial blood gases, and R. functions distribution within study group.

Table (2): Distribution of all outcome variables in study group.

Variables	Category	Number (Percentage)	p-value
• Basal metabolic index (BMI)	- Normal	19 (23.8%)	0.0001 *
	- Overweight	61 (76.3%)	
• Arterial blood gases (saO_2)	- Normal	77 (96.3%)	0.0001 *
	- Abnormal (hypoxic)	3 (3.8%)	
• R. functions	- Normal	54 (67.5%)	0.0001 *
	- Obstructive	11 (13.7%)	
	- Restrictive	15 (18.8%)	
• R. functions	- Normal	54 (67.5%)	0.0001 *
	- Mild	18 (22.5%)	
	- Moderate	7 (8.8%)	
	- Sever	1 (1.3%)	

Data are expressed as number (percentage.
p-value: Probability value.
*: Significant ($p<0.05$).

Spearman rank correlation coefficient (Table 3) and Fig. (1) was computed between total working time and R. functions. The results of these correlational analyses revealed that there were strong positive correlation between total working time and R. functions (r=0.68; p=0.0001; $p<0.05$). There were significantly ($p<0.05$) relation between working time and R. functions also, this means that change in the R. functions are consistent with change in total working time.

Table (3): Correlation between total working time and R. functions in study group.

Relation	*r*	*p*-value	Significance
Working time and R. functions	0.68	0.0001	S

r: Spearman rank correlation coefficient.
p-value: Probability value.
S: significant.

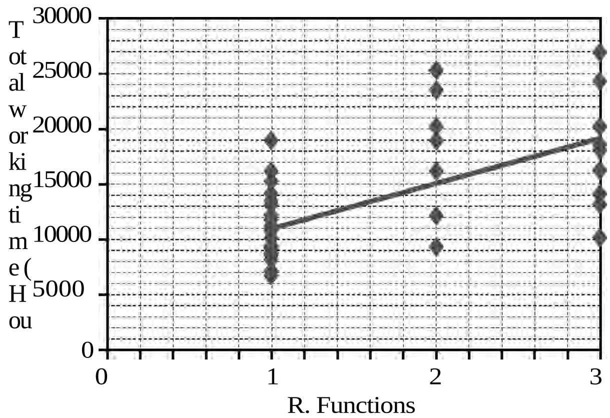

Fig. (1): Relation between total working time and R. function (1: Normal, 2: Obstructive, 3: Restrictive) in study group.

Discussion

This study was conducted to identify the effect of closed building syndrome on pulmonary function.

Eighty switch workers men with closed building syndrome were included in this study. Their age ranged from thirty to forty years old. They were recruited from from El-Kasr El-Ainy University Hospital. Before inclusion in this study full description of study, procedures for each patient and written consent had been signed. Subjects included in the study had the following criteria: Their working time ranged from 6-8 hours daily, had symptoms of CBS for more than 5 years, Their age ranged from 30-40 years old and their BMI ranged from 20 to 30kg/m^2. All men patients were evaluated with ventilatory function testing and arterial blood gases.

The findings of the study showed that: The mean values of age (year), weight (kg), height (cm), and BMI (kg/m^2) were 34.34±3.11, 74.02± 8.00, 168.67±5.96, and 26.02±1.90, respectively in study group. Number (percentage) of normal and abnormal (hypoxic) arterial blood gases distributions were 77 (96.3%) and 3 (3.8%), respectively. Number (percentage) of normal, obstructive and restrictive R. functions distributions were 54 (67.5%), 11 (13.7%), and 15 (18.8%), respectively. The mean value of total working was 83.91±14.75 hours with minimum and maximum values 6720.00 hour and 26880.00 hour, respectively. The mean value of respiratory functions was 87.09±14.38% with minimum and maximum values 60.20% and 103.3%, respectively. There was strong negative correlation between total working time and respiratory functions (r=0.68; p=0.0001; $p<0.05$). There was strong negative correlation between total working time and respiratory functions. The results showed that there was significant relation between working time and respiratory functions also, this means that change in the respiratory functions are consistent with change in total working time.

7 and 8 have concluded that lower ventilation rates are associated with higher SBS symptom prevalence rates, the analyses indicate that ventilation rates may have a considerable influence on symptom prevalence. For example, with a factor 2 decrease in ventilation rate starting from a ventilation rate of 10 l/s-person (the minimum required value in some codes and standards), the estimated increase in symptom prevalence is approximately 23%. Similarly, with a doubling of ventilation rate from 10 to 20 l/s-person, the estimated decrease in symptom prevalence is approximately 24%. The analyses also suggest that, on average, increases in ventilation rates above 25 l/s- person will not substantially reduce SBS symptom prevalence, although the uncertainty of our estimates are high in this ventilation rate range.

9 hypothesized that increased ventilation rates cause a decrease in indoor concentrations of indoor-generated air pollutants and that the decrease in pollutant concentrations causes a reduction in SBS symptoms via poorly understood mechanisms. With respect to the reduction in indoor pollutant concentrations, from mass balance calculations we know that the benefits (concentration decreases) per unit increase in ventilation rate diminish as ventilation rates get higher. However, with these assumptions, $_{Smid}$ should become nearly constant, remain slightly negative, and approach zero at high ventilation rates. The linear equation fitted to the

slope data is not able to match this expected behavior. With the same assumptions, one would expect the curve of RP to flatten out at high ventilation rates but always stay below unity.

A majority of the studies estimated ventilation rates in some or all buildings or spaces from measured airflow rates. These airflow rate measurements do not account for ventilation by air infiltration; thus, one would expect total ventilation rates in the study buildings to exceed the reported values. This bias is likely to have shifted the estimated curve of relative performance toward lower ventilation rates, resulting in underestimation of benefit at any specific ventilation rate. Insufficient data were available to quantify the magnitude of this effect **[9]**.

9 reported that SBS symptom prevalence rates in the original studies ranged from 3% to 44% in the cross-sectional or experimental studies and equaled 50% in a case-control study.

It is clear that considerable uncertainty remains with respect to the quantitative relationship between SBS symptoms and ventilation rates. However, decisions about minimum ventilation rates should also consider, as benefits of increased ventilation, what is known about the influence of ventilation rates on work performance **[10]**, communicable respiratory disease, and perceived indoor air quality **[7,8]**, and as costs of increased ventilation, what is known about the increased energy consumption required and the resulting greenhouse gas emissions sources. Thus, the present paper provides only an estimate of the average relationship.

Systematic analyses of available data suggest that ventilation rates have a considerable influence on SBS symptom prevalence. The analyses indicate that the average prevalence of SBS symptoms increases by approximately 23% as the ventilation rate drops from 10 to 5 l/s-person and decreases by approximately 29% as ventilation rate increases from 10 to 25 l/s-person. These estimates should be valuable inputs for decisions about appropriate minimum ventilation rates in once buildings. Experimental studies assessing how changes in ventilation rates influence SBS symptom prevalence rates are highly desirable to enable testing and refinement of the estimates provided in this paper, and to better document a causal relationship **[9]**.

Conclusion:

Based on the study, it was concluded that there was strong negative correlation between total working time and respiratory functions.

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تآثير متلازمة المبنى المغلق على وظائف التنفس

كانت متلازمة المبانى المغلقة منتشرة بشكل كبير بين العاملين فى المكاتب وتآثرت بظروف العمل الجسدية والنفسية الإجتماعية. ضعف الإضاءة، والتهوية السيئة، ونقص ضوء الشمس، وغياب التيارات الهوائية، والضوضاء العالية، ودرجة الحرارة، والرطوبة، ودخان التبغ البيئى، وإستخدام آلات التصوير، وعدم كفاية تنظيف المكاتب، إرتبطت إحصائياً بآعراض متلازمة المبانى المغلقة. آجريت هذه الدراسة لتقييم تآثير متلازمة المبانى المغلقة على وظائف الرئة.

فى هذه الدراسة تم تضمين ثمانين عاملاً فى التبديل من الرجال المصابين بمتلازمة المبانى المغلقة فى هذه الدراسة. تراوحت آعمارهم بين ثلاثين وآربعين سنة. تم تجنيدهم من مستشفى القصر العينى الجامعى. قبل تضمين الوصف الكامل للدراسة فى هذه الدراسة، تم التوقيع على إجراءات لكل مريض وموافقة كتابية. تم تقييم جميع المرضى من خلال إختبار وظائف التنفس الصناعى وغازات الدم الشريانى.

كان لدى الآشخاص الذين شملتهم الدراسة المعايير التالية: تراوح وقت عملهم من ٦–٨ ساعات يومياً، وكان لديهم آعراض متلازمة المبانى المغلقة لآكثر من ٥ سنوات، وتراوحت آعمارهم بين ٣٠–٤٠ عاماً وتراوح مؤشر كتلة الجسم لديهم من ٢٠ إلى ٣٠ كجم/م^{٢}.

تم إستبعاد الآشخاص من الدراسة الذين يعانون من الحالات آو الآمراض التالية: مشاكل القلب والآوعية الدموية غير المستقرة، آمراض الصدر، المدخنون وآمراض الآوعية الدموية الطرفية.

كانت هناك علاقة سلبية قوية بين إجمالى وقت العمل ووظائف الجهاز التنفسى. آظهرت النتائج آن هناك علاقة معنوية بين وقت العمل ووظائف الجهاز التنفسى آيضاً، وهذا يعنى آن التغيير فى وظائف الجهاز التنفسى يتوافق مع التغيير فى إجمالى وقت العمل.