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KLİNİK ÇALIŞMA
RESEARCH ARTICLE

Altered pulmonary functions due to biomass smoke in a rural population of Turkish women: a descriptive study

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SUMMARY

Altered pulmonary functions due to biomass smoke in a rural population of Turkish women: a descriptive study

Introduction: *Wood or other organic sources of fuel are used as source of energy for heating or cooking particularly in developing countries. The aim of the current study was to evaluate the association between biomass exposure time and parameters of pulmonary function tests.*

Materials and Methods: *Four hundred twenty-four consecutive women who lived and exposed to biomass smoke in a small province in Eastern Turkey were involved. This study was performed with women who had come to pulmonology out-patient clinic with symptom of dyspnea.*

Results: *The independent variables assessed in the study patients were age, BMI, starting age of cooking, hours per day and weeks per month spent cooking, and cooking years; the dependent variables were PFT parameters. Ninety-two (21.6%) patients had an obstructive PFT pattern. Sixty-seven (73%) of these patients were classified as GOLD 2 and 25 (27%) patients were classified as GOLD 3. Seventy-five (17.6 %) of the patients had restrictive lung disease; 54 (72%) of these patients were found to have a mild and 21 (27%) had a moderate restrictive pattern. Increased number of years in cooking and to start cooking at younger ages were a risk factors for the development of obstructive and restrictive disease. There was a statistically significant and negative correlation between increased number of years and the value of* FEV_1 *(r= -0.917; p=< 0.001),* FEV_1/FVC *(r= -0.739; p< 0.001), and FVC (r= -0.906; p< 0.001). The median time of cooking required was 23 years for the development of obstruction, and 25 years for restriction, respectively.*

Conclusion: *Cumulative biomass exposure time is associated with impairment in PFT parameters; results in both obstructive and*

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restrictive lung disease. Biomass exposure is a public health problem and pre-cautions should be taken in order to prevent impaired pulmonary functions.

Key words: *Biomass; pulmonary function testing; exposure*

ÖZET

Kırsal alanda yaşayan kadınlarda biyomas dumanına bağlı solunum fonksiyon kapasitesinde bozulma

Giriş: *Odun ve organik maddeler, özellikle gelişmekte olan ülkelerde ısınma ve yemek pişirme amaçlı enerji kaynağı olarak kullanılmaktadır. Bu çalışmada biyomas dumanına maruz kalınan süre ile bozulan solunum fonksiyon testi parametreleri arasındaki ilişki değerlendirilmiştir.*

Materyal ve Metod: *Bu çalışma doğuanadolu bölgesinde bir kasabada yaşayan biyomas dumanına maruz kalmış kadınlarla yapılmıştır. Hastalar göğüs hastalıkları polikliniğine nefes darlığı ile başvuran kişiler arasında seçilmiştir.*

Bulgular: *Bağımlı değişken, solunum fonksiyon testi sonuçları ve bağımsız değişkenler, yaş, vücut kitle indeksi, tandır yapmaya başlama yaşı, ayın kaç haftası tandır yaptığı, tandır başında geçen süre (saat), toplam tandır süresi (yıl). Hastaların 92 (%21.6)'sinde obstrüktif patern gözlenmiş, ve bu hastaların 67 (%73)'si GOLD 2.25 (%27)'i GOLD 3 olarak sınıflandırılmıştır. Hastaların 75'inde restriktif paterne rastlanmış ve bu hastaların 54 (%72)'ü hafif, 21 (%28)'i orta restritif tiptedir. Erken yaşta tandır yapmaya başlamak ve tandır başında geçen süre (yıl) restriktif ve obstrüktif akciğer hastalığı gelişmesinde risk faktörüdür. Tandır yılı ile FEV_1 (r= -0.917; p= < 0.001), FEV_1/FVC (r= -0.739; p< 0.001) ve FVC (r= -0906; p< 0.001) arasında negatif korelasyon vardır. Hastalarda obstrüksiyon gelişmesi için toplam 23 yıl ve restriksiyon gelişmesi için de 25 yıl tandır yapılması gerekmektedir.*

Sonuç: *Tandır yapımında geçen süre arttıkça hastalarda hem restriktif hem de obstrüktif tipte solunum yetmezliği gözlenmektedir. Biyomasa maruz kalmaya bağlı ortaya çıkan bu halk sağlığı problemine karşı gerekli önlemler alınmalıdır.*

Anahtar kelimeler: *Biyomas; solunum fonksiyon testi; maruziyet*

INTRODUCTION

Wood and other sources of fuel such as animal dung and organic food products are used as a source of energy for heating and cooking, particularly in developing countries (1,2). Approximately 3 billion people worldwide are exposed to biomass fuel smoke (3). Chronic obstructive pulmonary disease (COPD) is increasingly becoming a serious public health problem (4). Smoking is a leading risk factor for the development of COPD in developed countries and in the male population; however, biomass exposure is another important risk factor in the development of COPD in places where indoor ventilation is insufficient (2,5). Biomass exposure is associated with changes in pulmonary tissue. It causes fibrosis in lung architecture, particularly in individuals who use non-wood organic materials as a fuel source, and this exposure can cause restrictive pulmonary disease (6-9). Many studies have shown a relationship between COPD and biomass exposure by analyzing subgroups according to sex, smoking status, and source of energy used as fuel (10-14). However, very few of these studies have clearly identified a critical period of time for the development of pulmonary disease. The aim of the present study was to evaluate the relationship between the parameters of the pulmonary function test and the duration.

MATERIALS and METHODS

Study Design

Many women who live in the villages in the Eastern Anatolia Region of Turkey are involved in cooking bread in floor furnaces (tandoor). These individuals are exposed to heavy smoke due to the cooking principles (lack of chimney and poor smoke ventilation) (Figure 1). Dry animal dung (manure), rather than wood and charcoal, is used as the fuel source (Figure 2). This study was performed between January 2013 and December 2013 among women who had come to pulmonology out-patient clinic of Kagizman state hospital with symptom of dyspnea. In one year period 945 women were evaluated; current and former smokers; patients with known heart failure, chronic renal failure, history of bronchiectasis, asthma and allergy; those who had received therapy due to upper or lower respiratory infections in the past month were excluded from the study, and the patients who did not want to participate the study were excluded, and finally with 424 women the study was performed.

Pulmonary function tests (PFT) were performed after obtaining the patient's consent for the study. A PFT device (MIR; Spirolab III; USA) was used on each patient after being calibrated by a PFT technician, and best of three acceptable with good graphs of spirometry

Figure 1. Lack of chimney and poor smoke ventilation.

was accepted. Post-bronchodilator forced expiratory volume (FEV_1), forced vital capacity (FVC), and forced expiratory flow (FEF) 25-75% parameters were recorded. $FEV_1/FVC < 70\%$ as obstruction, and $FVC < 80\%$ plus $FEV_1/FVC > 70$ as restriction, based on the standardized parameters determined by the American Thoracic Society (ATS)/European Respiratory Society (ERS) (15). Patients who were diagnosed as having COPD were classified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) as mild, moderate, severe, and very severe (16). In terms of restriction, FVC > 80 mL were classified as normal, 65-80 mL as mild, 51-65 mL as moderate, and < 50 mL as severe restriction (17). Beside PFT results of the patients, the association between the duration of biomass smoke with obstructive and restrictive lung disease were evaluated.

The study was conducted in accordance with the guidelines of the "Declaration of Helsinki" and approved by the local ethical committee of Kars provenience.

Figure 2. Dry animal dung (manure), rather than wood and charcoal, is used as source of energy.

Statistics

SPSS (Statistical Packages for the Social Sciences) version 21.0 (IBM Corporation, Armonk, NY, USA) and Med Calc statistical software were used in the statistical analyses. Descriptive statistics [frequency, percentage, mean (min-max)] were used to evaluate the study data. The independent sample t-test was used to compare parameters between the groups. A one-way ANOVA test was used to compare the parameters between more than one group, and the Bonferroni test was used to determine the group that showed a significant difference. Pearson's correlation analysis was used to evaluate the relationship between duration as years, and PFT. A ROC curve analysis was performed to determine the cut-off levels of the parameters, and sensitivity and specificity were calculated based on the cut-off value.

RESULTS

A total of 424 eligible patients were included in the study. The independent variables assessed in the study patients were age, BMI, starting age of cooking, hours per day and weeks per month spent cooking, and cooking years; the dependent variables were PFT parameters (Table 1). The distribution of the patients based on PFT results was as given in figure 3.

Of the patients evaluated in the study, 92 (21.6%) had an obstructive PFT pattern. Sixty-seven (73%) of these patients were classified as GOLD 2 (moderate obstruction) and 25 (27%) patients were classified as GOLD 3 (severe obstruction). Seventy-five (17.6 %) of the patients had restrictive lung disease; 54 (72%) of these patients were found to have a mild restriction and 21 (27%) had a moderate restrictive pattern.

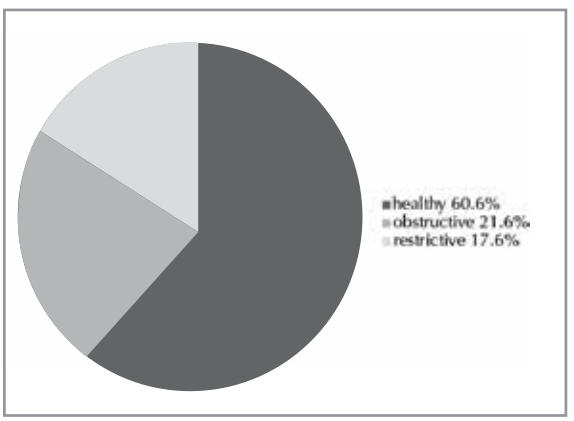

Figure 3. Distribution of pulmonary function test results among the evaluated patients.

Table 1. Median values of evaluated dependent and independent parameters

Variables	n (min-max)
Age	41.5 (18-86)
BMI	26.2 (20.1-42.9)
Starting age	18.1 (11-49)
Daily hours spent in cooking	3.2 (1-5)
Weeks/month spent in cooking	3.2 (1-4)
Total years spent in cooking	20.6 (1-65)
FEV_1 (Lt)	1.92 (0.58-3.46)
FEV_1 (%)	69 (39-97)
FVC (Lt)	2.54 (0.95-3.96)
FVC (%)	81 (51-99)
FEV_1/FVC (%)	74 (52-96)
FEF 25-75 (%)	59 (32-115)

FEV_1 (forced expiratory volume), FVC (forced vital capacity), FEF 25-75 (forced expiratory flow), BMI (body mass index).

In table 2 associations between PFTs and independent variables (age, hours per day, weeks per month, and total years) were evaluated. There was a negative and statistically significant relationship between starting to cook in smaller ages and existence of both obstructive and restrictive pulmonary functions. Moreover, there was a positive and statistically significant relationship between total years spent in cooking and altered pulmonary functions. However there was no statistically significant between hours per day, and weeks per month and altered pulmonary functions.

Figure 4 summarizes the correlation analysis between duration of exposure in years and PFT parameters. There was a statistically significant and negative correlation between increased number of years and the value of FEV_1 ($r= -0.917$; $p= < 0.001$), FEV_1/FVC ($r= -0.739$; $p< 0.001$), and FVC ($r= -0.906$; $p< 0.001$). We also did ROC curve analysis in order to determine the required number of years for existence of pathologic PFT patterns. The median time of cooking required was 23 years for the development of obstruction, and 25 years for restriction, respectively (Figure 5).

Table 2. Relationship between independent variables and altered pulmonary function test results

Variables	Obstructive disease (+)	Obstructive disease (-)	p
Starting age	17.7	20.100	**0.001**
Hours per day	3.1	2.8	0.327
Weeks per month	2.6	2.4	0.110
Total years	37.5	16.1	**0.001**
	Restrictive disease (+)	**Restrictive disease (-)**	
Starting age	17.7	20.9	**0.001**
Hours per day	3.1	2.8	0.321
Weeks per month	2.6	2.4	0.109
Total years	31.5	8.6	**0.001**

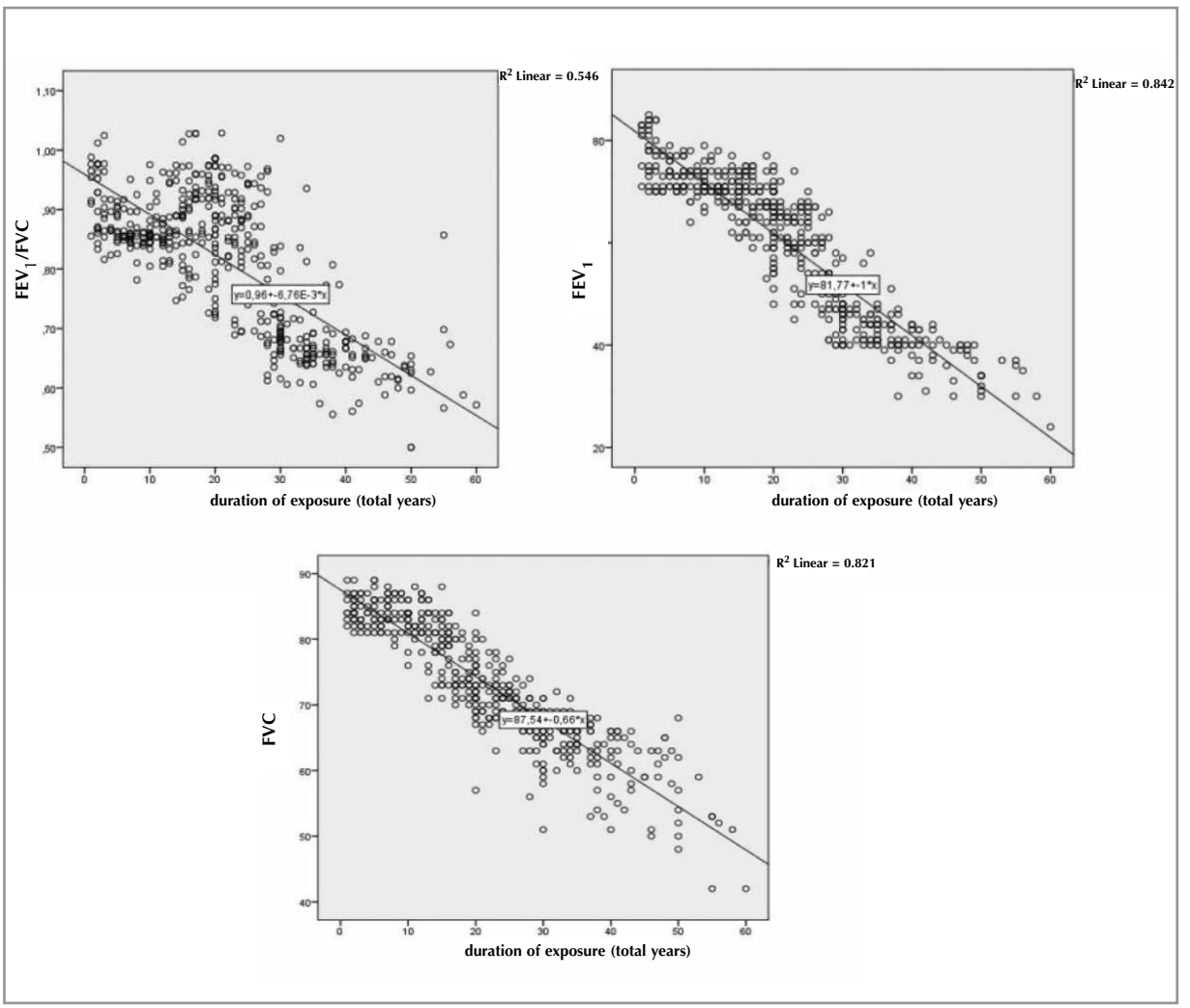

Figure 4. Graphics of correlation analysis between duration (total exposure year) with FEV_1, FEV_1/FVC, FVC.

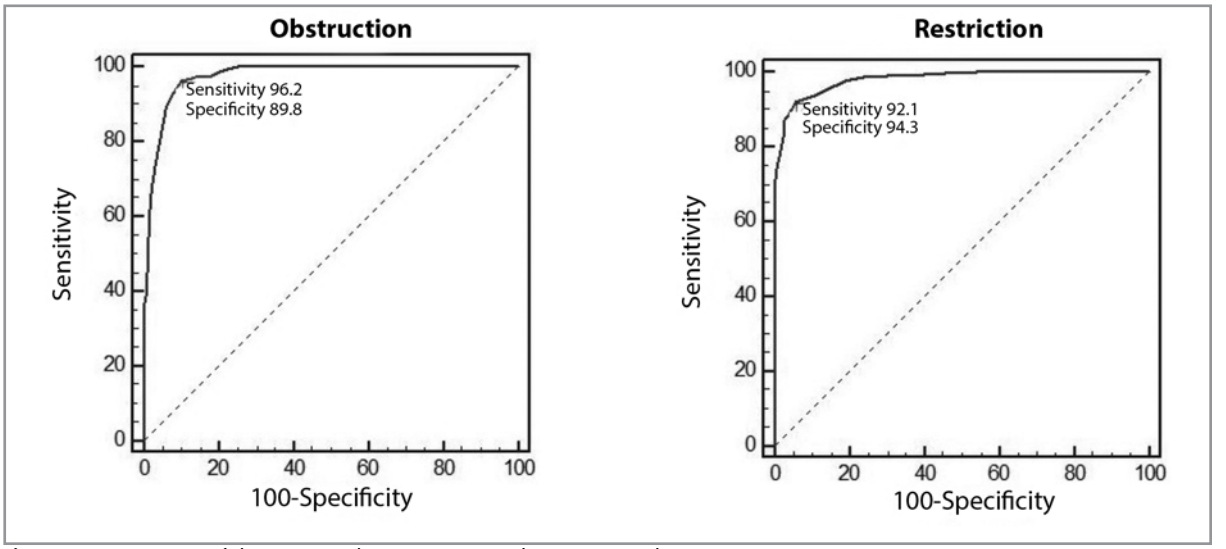

Figure 5. ROC curves of duration (total exposure year) obstruction, and restriction.

DISCUSSION

In this cross-sectional study, we found that increased number of cooking year is related to altered PFT results. As the duration of biomass exposure increased, the possibility of severity of obstruction and restriction was higher. There was a negative correlation between number of years spent cooking and PFT parameters. There were also cut-off values for the duration for the existence of altered PFT results.

Chronic biomass exposure causes infiltration of macrophages in the alveolar space, thickening in the bronchial wall, and a continuous inflammatory process in the airways, which results in an impairment in pulmonary function (18). In the present study, FEV_1, and FVC values decreased with increased duration of exposure to biomass smoke, 92 patients were found to have COPD according to the GOLD classification, and the probability, and the severity of COPD increased with increasing years of exposure. Similar results were reported in the studies by Ramirez Venegas et al. and Regalado et al. (19,20). These authors found that COPD developed in subjects exposed to biomass and reported advanced stages of COPD with increased duration and intensity of exposure. In another study, PFT parameters were evaluated in subjects with biomass exposure; although no statistically significant difference was observed, possibly due to the low number of subjects, the likelihood of developing COPD was higher in patients who were exposed to biomass smoke (21). Studies by Sezer et al. Ekici et al. and Gunen et al. conducted in Turkey showed a relationship between biomass exposure and the development of COPD (11,13,22). Biomass exposure is the second most important risk factor for the development of COPD; however, the question is how soon individuals develop COPD after initiation of biomass exposure. Although recent studies about biomass exposure did not mention a specific time period as in our study (23 years), Caballero et al. estimated 10 years and above, and Dossing et al. estimated 20 years and above, as the time period for the development of COPD (10,14). In a similar study by Orozco-Levi et al., the mean duration of biomass exposure was 18 years in patients with COPD, and they suggested that the risk of developing COPD was higher as the duration of exposure increased (12).

In the present study, spirometric analysis revealed FVC < 80% in 75 patients. According to the information in the literature, obstructive pattern respiratory disease is anticipated in subjects with biomass exposure. Animal dung (manure) was the source of energy of biomass fuel in our study. Burning dry dung results in various reactions that cause fibrosis in lung tissue, and this is associated with the development of restrictive lung disease. In the studies by Arslan et al. and Kara et al. , computerized tomography (CT) of the lungs of patients with biomass exposure revealed fibrotic bands, nodular opacities, and perivascular thickening, which are the radiologic signs of restrictive lung disease; therefore, the authors suggested restrictive pulmonary disease could be seen in these patients (6,7). In another study, Rinne

et al. observed restrictive lung disease in children with biomass exposure; however, in contrast to the literature, obstruction ($FEV_1/FVC < 0.7$) was not observed in these children despite decreased FEV_1 values (8). In the study by Kargin et al., the authors evaluated 46 patients who had biomass exposure, and similar to our results, they suggested biomass exposure may be the reason for combined restrictive and obstructive pulmonary disease (9).

There is a positive correlation between number of years and value of CEI with altered pulmonary functions. When the duration of biomass smoke exposure is high, the probability of pulmonary dysfunction is also elevated, as would be expected. This finding is consistent with findings of prior studies (9,13,14).

STUDY LIMITATIONS

If it were possible to perform pulmonary imaging studies, particularly computerized tomography of the lungs, it would be possible to differentiate chronic bronchitis from emphysema and show reticulonodular appearance and fibrosis that could cause restrictive patterns. However, the main focus of the present study was to determine the relationship between biomass exposure and changes in pulmonary function tests, and not to reach conclusions based on imaging studies.

In conclusion, biomass exposure is associated with impairments in the parameters of RFT. A respiratory disease characterized by an obstructive pattern is inevitable, as would be expected for patients who were exposed to smoke. The use of organic materials (dry animal dung) as a fuel source, as in the present study, may cause pulmonary fibrosis and, as a result, lead to restrictive pulmonary disease.

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