JBACHS
Journal of Basic and Clinical Health Sciences

J Basic Clin Health Sci 2021; 3: 23- 29
https://doi.org/10.30621/jbachs.879109

THE PREDICTORS OF THE PULMONARY FUNCTION IN COMMUNITY-DWELLING OLDER ADULTS

Serkan Bakirhan[1], Mehmet Ozkeskin[1], Sevnaz Sahin[2], Fatih Ozden[3]

[1] Ege University, Faculty of Health Sciences, Physiotherapy and Rehabilitation Department, Izmir, Turkey
[2] Ege University, Faculty of Medicine, Department of Internal Medicine, Division of Geriatrics, Izmir, Turkey
[3] Muğla Sıtkı Koçman University, Köyceğiz Vocational School of Health Services, Elderly Care Department, Muğla, Turkey

Address for Correspondence: Serkan Bakırhan, PT. PhD, **E-mail:** serkan.bakirhan@ege.edu.tr
Received: 12.02.2021; **Accepted:** 11.08.2021; **Available Online Date:** 20.09.2021

Cite this article as: Bakirhan S, Ozkeskin M, Sahin S, Ozden F. The predictors of the pulmonary function in community-dwelling older adults. J Basic Clin Health Sci 2021; 3: 23- 29.

ABSTRACT

Purpose: The aim of the study was to observe the relationship between age, body mass index (BMI), physical activity, and kyphosis angle parameters with respiratory function capacity in community-dwelling older adults and to determine the main predictor.

Methods: A prospective cross-sectional study was carried out with 70 older adults. Physical activity level was questioned with the Physical Activity Scale for Elderly (PASE). Thoracic kyphosis degrees were measured with a digital inclinometer. Pulmonary Function Test (PFT) was used to measure pulmonary function capacity. The correlation between age, BMI, PASE, thoracic kyphosis angle with parameters of PFT measurement was analyzed. In addition, a linear multivariate regression model was built to determine the main predictor.

Results: The mean age of the participants was 69.88±4.52 years. There was a low degree but a statistically significant positive correlation between BMI and FEV1 (r=0.258, p<0.05). BMI was also associated with FEV1/FVC (r=0.338, p<0.001). PASE was related with FVC, FEV1 and PEF (r1=0.241, p<0.05; r2=0.281, p<0.05;r3=0.317,p<0.001). In the multivariate linear regression model, higher levels of PASE score were associated with higher levels of FVC (standardized ß=0.25, p<0.05). The high PASE score was associated with a high FEV1 score (standardized ß=0.30, p<0.05). BMI was the main predictor of FEV1/FVC (standardized ß=0.34, p<0.001). Besides, PASE was the main predictor of PEF (standardized ß=0.32, p<0.001).

Conclusion: According to the results of the study, greater levels of physical activity and body mass index were associated with greater levels of pulmonary function capacity. Physical activity level was the main predictor for all pulmonary function parameters except FEV1/FVC.

Keywords: Physical activity; respiratory function; elderly; thoracic kyphosis

INTRODUCTION

Respiratory functions decrease with the deterioration of lung functions due to aging. The reduction of forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) predisposes lung diseases and other chronic conditions. Decreased pulmonary function capacity is primarily associated with mortality and morbidity (1, 2). Various factors contribute to these age-related conditions in lung functions. Active smoking is the primary factor; body mass index, body fat distribution, physical activity, dietary content, and comorbid cardiovascular conditions also lead to loss of pulmonary functions (3, 4). Older adults tend to have a sedentary life that becomes prominent with a progressive decrease in muscle strength and sarcopenia, and the level of physical activity decreases (5, 6). In addition, another risk factor for the decrease of pulmonary function is the thoracic hyperkyphotic posture that occurs with aging (7).

The average physiological degree of kyphosis is between 20 and 40 degrees, and this angle increases with age (8, 9). Many destructive changes occur in the chest wall with changes in the spine and costovertebral joints with changes in axial loads due to the increase in the degree of kyphosis. The increasing degree of thoracic kyphosis changes the thorax's shape, causing an increase in the anteroposterior diameter and changes in the thorax's position surrounding the abdominal cavity by decreasing the distance between the xiphoid process and the pubis. These rib cage changes result in a decrease in the mobility of the ribs, changes in the respiratory system's biomechanics, and decreases in respiratory muscle strength and respiratory function tests (10).

Postural disturbances occurring due to physical inactivity cause an increase in the degrees of thoracic kyphosis. Kyphotic posture is observed with the weakening of the diaphragm, transversus abdominus, and pelvic floor muscles (especially the back extensors), which are one of the back group antigravity muscles, in the anterior group muscles (11). Physical activity also directly affects respiratory functions. Therefore, pulmonary evaluation should be considered comprehensively and should be evaluated as one of the primary risk factors leading to a decrease in pulmonary capacity (12, 13).

In the literature, the relationship between pulmonary function tests with the degree of thoracic kyphosis and the level of physical activity in healthy elderly individuals has not been well studied. Age, body mass index, kyphosis angle, and physical activity level should also be handled by regression analysis in order to demonstrate which may affect respiratory function tests more. The aim of the study was to observe the relationship between age, body mass index (BMI), physical activity, and kyphosis angle parameters with respiratory function capacity in community-dwelling older adults and to determine the main predictor.

MATERIALS AND METHODS

Study Design and Participants

A prospective cross-sectional study was carried out with 70 older adults between October 2019 and September 2020 at Ege University, Department of Internal Medicine/Geriatrics. Measurement of the individuals was conducted in the clinical office of the training and research hospital. The inclusion criteria were; (1) older adults ≥65 years, (2) patients followed up in a geriatric clinic. The exclusion criteria of the study were; (1) a history of thoracic and vertebral surgery, (2) cardiopulmonary, neurological, and psychiatric disorders, (3) patients who do not give consent to participate in the study.

Procedure

Participants were given detailed information about the study and their consents were obtained. The questionnaire forms were filled under the supervision of two physiotherapists with at least 20 years of experience, and all other practice-based evaluations were carried out by the same researchers for all individuals. Individual characteristics (e.g., age, height, weight, body mass index, gender, smoking, health history) of the individuals were recorded. Physical activity levels of the individuals were questioned face to face using the Turkish version of the Physical Activity Scale for Elderly (PASE) (14). Thoracic kyphosis degrees of all participants were measured with a digital inclinometer device (Baseline Digital Inclinometer, Fabrication Enterprises, White Plains, NY) with reference to the spinous processes of the 1st thoracic and 12th thoracic vertebra while arms at the sides, in regular standing posture (15). Pulmonary Function Test (PFT) device (Pony FX, COSMED Inc., Italy) was used to measure lung capacities. Peak expiratory pressure (PEF), forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC (%) parameters were measured with the PFT device.

Table 1. The individual characteristics of the older adults

n:70	**Total**
Age (years, mean±SD)	69.88±4.52
Gender (n, %)	
Women	36 (51.4)
Men	34 (48.6)
Weight (kg, mean±SD)	74.70±10.86
Height (cm, mean±SD)	163.24±8.91
BMI (kg/m², mean±SD)	28.13±4.18

SD: standard deviation, n: number of patients, BMI: Body mass index

Sample Size Estimation

G*power 3 was used for the sample size calculation. The parameters were set to f=0.3, alpha level=0.05 and power=0.80 (16, 17). At least 64 participants were required. Initially, 78 older adults were included in the study, but eight were excluded because they had the exclusion criteria. Accordingly, 70 patients were included in the study. Informed consent of the patients was obtained.

Table 2. Absolute values (mean, standard deviation, min-max) of the assessments

n:70	Mean±SD	Range
PASE	111.28±65.89	(35-327)
Kyphosis angle	35.30±5.93	(23-51)
FVC (%)	70.91±32.32	(7-144)
FEV_1 (%)	69.45±28.26	(10-123)
FEV1 / FVC (%)	99.07±17.95	(37-131)
PEF (%)	57.38±27.71	(8-115)

SD: standard deviation, n: number of patients, PASE: Physical Activity Scale for the Elderly, PFT: Pulmonary Function Test, PEF: Peak expiratory pressure, FEV_1: forced expiratory volume in the first second, FVC: Forced vital capacity

Outcome Measurements

Physical Activity Scale for Elderly (PASE): The Turkish version of the Physical Activity Scale for the Elderly was used to assess the physical activity of individuals. PASE was developed to measure the components of physical activity related to home, work, and leisure. PASE questions mild, moderate, and vigorous activities. The physical activities are examined comprehensively by PASE (14, 18).

Thoracic Kyphosis Angle Measurement: The thoracic kyphosis angle was measured with a digital inclinometer device with two sensors. Before using the device, both sensors were placed vertically on a flat surface and the angle values were reset. Conditions suitable for the calibration of the device have been established. Participants were asked to look to the opposite side, in normal standing and relaxed posture with arms at their sides. While the thoracic region was open, the spinous processes of the 1st thoracic vertebra and the 12th thoracic vertebra were palpated and marked. The angle values of these points were measured separately by pressing the start button. The angle values obtained from the spinous points of the 1st thoracic and 12th thoracic vertebra was summed and the total kyphosis angle values of the cases were recorded after the evaluation was repeated three times and after calculating the mean value (15).

Pulmonary Function Tests (PFT): Peak expiratory pressure (PEF), forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), FEV_1/FVC (%) parameters were evaluated. In all measurements, the participants were in a sitting position in arm supported chair. Their noses were closed with a pincer, they were asked to exhale strongly and for a long time, immediately after a deep inspiration, after normal breathing through a disposable filter mouthpiece with a respiratory function tester. The best value of the three measurement was recorded (19, 20).

Statistical Analysis

SPSS (Statistical Package for Social Sciences, 25.0 version, IBM Corp, Armonk, New York) was used for the statistical analysis. The confidence interval of 95% was accepted. Kolmogorov-Smirnov test was used to show the appropriateness of the normal distribution in decision making for correlation analysis. Pearson's correlation coefficient (r) was preferred because the data conformed to a normal distribution and the sample size was ≥50. The correlation between age, BMI, PASE, thoracic kyphosis angle with parameters of PFT measurement was analyzed. The Pearson correlation coefficients were interpreted as; 0-0.2= very low, 0.21-0.40= low, 0.40-0.70= medium, 0.71-0.90= high, 0.91-1.0= very high (21). Also, a linear multivariate regression model has built with parameters which has a statistically significant correlation coefficient with respiratory function parameters to reveal the predictors of respiratory function scores.

RESULTS

A total of 70 elderly adults (36 women, 34 men) with a mean age of 69.88±4.52 (ranged, 65-83) years were included in the study. More than half of the participants were female (51.4%). Body mass index (BMI) mean was 28.13±4.18, participants were overweight. None of the patients were active smokers. Characteristics of the elderly are given in Table 1. The absolute values of the PASE, kyphosis angle measurement and PFT measurements were presented in Table 2.

Table 3. The correlation between age, BMI, PASE, thoracic kyphosis angle with PFT

n: 70	FVC (%)	FEV_1 (%)	FEV_1 / FVC (%)	PEF (%)
Age	-0,066	-0,066	0,093	-0,079
BMI	0,153	0,258*	0,338**	0,100
PASE	0,241*	0,281*	0,039	0,317**
Kyphosis angle	0,094	-0,079	-0,161	-0,091

*: p<0.05, **: p<0.001, n: number of patients, BMI: Body mass index, PASE: Physical Activity Scale for the Elderly, PFT: Pulmonary Function Test, PEF: Peak expiratory pressure, FEV_1: forced expiratory volume in the first second, FVC: Forced vital capacity

Table 4. Multivariable Linear Regression Analysis with FVC as the Outcome

n:70				95% CI for Standardized ß	
	Unstandardized ß	Standardized ß	p	Lower Limit	Upper Limit
PASE	1.336	0.254	0.033	0.010	0.239
BMI	0.125	0.173	0.145	-0.470	3.142

*: p<0.05, **: p<0.001, n: number of patients, BMI: Body mass index, PASE: Physical Activity Scale for the Elderly, Differences statistically significant. R2= 0.09; Durbin-Watson's coefficient = 1.98; VIF<1.15; and tolerance over = 0.9, VIF: variance inflation factor

The correlation between age, BMI, PASE, thoracic kyphosis angle with parameters of PFT measurement is presented in Table 3. There was a low degree but a statistically significant positive correlation between BMI and FEV_1 ($r = 0.258$, $p < 0.05$) (Figure 1, Table 3). BMI was also associated with FEV_1/FVC ($r = 0.338$, $p < 0.001$) (Figure 2, Table 3). PASE was both related with FVC, FEV_1 and PEF (r_1=0,241, p<0.05; r_2=0,281, p<0.05; r_3=0,317, p<0.001) (Figure 3-5, Table 3). In our multivariate linear regression model, higher levels of PASE score were associated with higher levels of FVC (standardized ß = 0.25, p <0.05) (Table 4). In the regression model analyzed to observe the predictor of FEV_1, a high PASE score was associated with a high FEV_1 score (standardized ß = 0.30, P <0.05) (Table 5). On the other hand, in regression with FEV_1 / FVC as the outcome, BMI was the main predictor (standardized ß = 0.34, P <0.001) (Table 6). In addition, in the linear model created for PEF, PASE was the main predictor (standardized ß = 0.32, p <0.001) (Table 7). R^2, Durbin-Watson's coefficient and variance inflation factor (VIF) scores for each model are presented in the relevant table.

DISCUSSION

The present study aimed to observe the relationship between age, body mass index (BMI), physical activity, and kyphosis angle parameters with respiratory function capacity in community-dwelling older adults and determine the main predictor. In addition, we purposed to reveal the most related parameter with pulmonary function capacity. For this objective, we determined the most relevant factor in a linear regression model built with the parameters related to the four parameters (FVC, FEV_1, FEV_1/FVC (%) PEF), measured in the pulmonary function test. According to the results, greater physical activity and body mass index levels were associated with greater pulmonary function capacity levels. Besides, physical activity level was the main predictor for all pulmonary function parameters except FEV_1 / FVC.

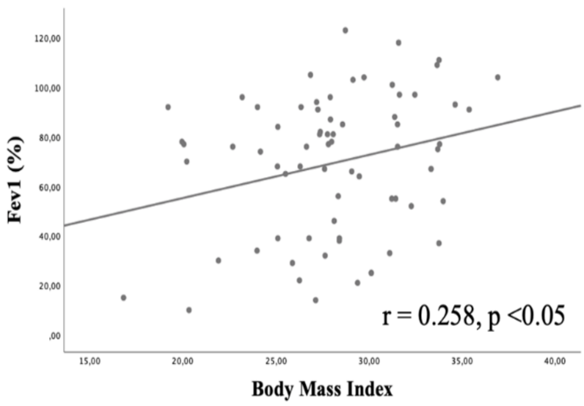

Figure 1. Correlation between BMI and FEV1

Many studies have investigated the relationship between age, body composition (e.g., body mass index, fat distribution), physical activity level, and thoracic kyphosis angle with pulmonary function tests as independent parameters (1, 3, 12, 22, 23). However, to the best of our knowledge, no previous studies investigated these three parameters simultaneously with regression analysis. Studies show that the effect of active smoking is primary (2, 3, 24). For this reason, we did not include active smokers in older adults for our study. We focused primarily on the correlational analysis of the parameters. In addition, we researched the main predictor of which was the most influential factor in terms of causality.

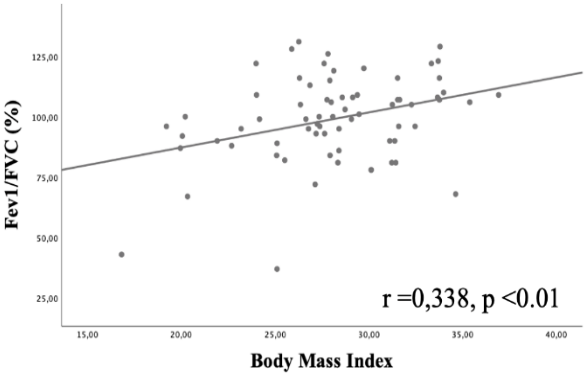

Figure 2. Correlation between BMI and FEV1 / FVC

In a longitudinal study involving follow-up for seven years, Rossi et al. investigated the relationship between body composition and respiratory functions in older adults. They performed the pulmonary function tests with spirometry as in our study. According to the results of the study, it was observed that respiratory functions were related in terms of fat-free mass and fat mass rather than body mass index (1). In addition, in a cross-sectional study conducted with a large population of 2744 people, it is seen that the increase in body mass index in elderly male individuals is characterized by a decrease in respiratory functions (FVC, FEV_1) (25). In our study, it was observed that the higher the body mass index, the higher the FEV_1 and FEV_1/FVC (%) values. Our results were different from these more comprehensive studies. We thought that the individuals in our sample could be individuals with high respiratory muscle strength without sarcopenic obesity. However, considering our pragmatic study design, the main limitation of the study is not to include these parameters since the device and time possibilities were inadequate.

Kyphosis is the other factor thought to play a role in the reduction of respiratory function capacity. Ab Rahman and colleagues showed that FEV_1 decreased with an increase in the angle of thoracic kyphosis in older adults. Ab Rahman and colleagues showed that FEV_1 decreased with an increase in the angle of thoracic kyphosis in older adults (26). In another cross-sectional study, the kyphosis angle was found to be associated with both restrictive and interventional ventilatory patterns in community-dwelling older adults (27). In a prospective cohort study, Lorbergs et al. concluded that greater kyphosis is associated with pulmonary function decline in women but not in men. It was emphasized that there might be no relationship due to the low number of cases in men (22). In our study, we assume that there may not have been a relationship due to the relatively low number of cases in our study and the low number of cases with kyphosis grade>40. The fact that the angle is not measured more clearly with an X-ray with the inclinometer can be considered another limitation of the study. Because although the inclinometer is reliable, it may not be as effective as an X-ray in terms of sensitivity.

Table 5. Multivariable Linear Regression Analysis with FEV_1 as the Outcome

n:70				95% CI for Standardized ß	
	Unstandardized ß	Standardized ß	p	Lower Limit	Upper Limit
PASE	0.130	0.303	0.009	0.034	0.226
BMI	1.906	0.282	0.015	0.338	3.423

*: p<0.05, **: p<0.001, n: number of patients, BMI: Body mass index, PASE: Physical Activity Scale for the Elderly, Differences statistically significant. R2= 0.16; Durbin-Watson's coefficient = 2.00; VIF<1.15; and tolerance over = 0.9, VIF: variance inflation factor

Table 6. Multivariable Linear Regression Analysis with FEV_1 / FVC as the Outcome

n:70				95% CI for Standardized ß	
	Unstandardized ß	Standardized ß	p	Lower Limit	Upper Limit
PASE	0.018	0.031	0.566	-0.045	0.081
BMI	1.472	0.343	0.004	0.486	2.458

*: p<0.05, **: p<0.001, n: number of patients, BMI: Body mass index, PASE: Physical Activity Scale for the Elderly, Differences statistically significant. R2= 0.12; Durbin-Watson's coefficient = 2.13; VIF<1.15; and tolerance over = 0.9, VIF: variance inflation factor

Table 7. Multivariable Linear Regression Analysis with PEF as the Outcome

n:70				95% CI for Standardized ß	
	Unstandardized ß	Standardized ß	p	Lower Limit	Upper Limit
PASE	0.138	0.327	0.006	0.041	0.234
BMI	0.836	0.126	0.277	-0.688	2.360

*: $p<0.05$, **: $p<0.001$, n: number of patients, BMI: Body mass index, PASE: Physical Activity Scale for the Elderly, Differences statistically significant. R^2= 0.12; Durbin-Watson's coefficient = 1.80; VIF<1.15; and tolerance over = 0.9, VIF: variance inflation factor

.

Physical activity is another parameter thought to be primarily associated with lung functions. Kaneko stated that according to the preliminary findings in a cross-sectional study, pulmonary function is associated with physical performance, physical activity, and sedentary lifestyle (12). In a comprehensive systematic review, physical activity was found to increase respiratory muscle strength (28). In the review of Aksovic et al., the contribution of physical activity, including aerobic exercises, to respiratory functions in the elderly population was mentioned (29). In our study, the number of cases was 70. We calculated this number by taking into account the minimum requirements for statistical analysis by power analysis. However, considering that different factors could have different results on respiratory functions in men and women, it is aimed to achieve an almost equal number of gender distributions. Also, increasing the sample size may still be more effective in terms of the precision of the regression analysis. In addition to our pulmonary function tests, the measurement of respiratory muscle strength could further support our results. We also consider this situation as a limitation, and we recommend that researchers focus on this parameter in further studies. Finally, instead of building linear regression analysis with correlated parameters, it could be considered to look at causality at the hierarchical level with stepwise regression. However, when we consider the number of our cases, we thought our methodological selection would be more effective.

CONCLUSION

According to the results of our statistical analysis, greater levels of physical activity and body mass index were associated with greater levels of pulmonary function capacity. In addition, we concluded that physical activity level was the main predictor for all pulmonary function parameters except FEV_1/FVC.

Acknowledgements: None.

Ethics Committee Approval: The study was carried out in accordance with the ethical principles and the Helsinki Declaration. Informed consent of the patients was obtained. The study protocol was approved by the ethics committee of Ege University (19-5.1T/25).

Financial Disclosure: The authors would like to thank Ege University Scientific Research Projects Coordination Unit for their financial support to this project (TGA-2019-20857).

Informed Consent: Informed consents of the patients were obtained.

Peer-review: Externally peer-reviewed.

REFERENCES

1. Rossi A, Fantin F, Di Francesco V, Guariento S, Giuliano K, Fontana G, et al. Body composition and pulmonary function in the elderly: a 7-year longitudinal study. Int J Obes. 2008;32(9):1423-30.
2. Benadjaoud MA, Menai M, van Hees VT, Zipunnikov V, Regnaux J-P, Kivimäki M, et al. The association between accelerometer-assessed physical activity and respiratory function in older adults differs between smokers and non-smokers. Sci rep. 2019;9(1):1-9.
3. Burchfiel CM, Enright PL, Sharp DS, Chyou P-H, Rodriguez BL, Curb JD. Factors associated with variations in pulmonary function among elderly Japanese-American men. Chest. 1997;112(1):87-97.
4. O'Donovan G, Hamer M. The association between leisure-time physical activity and lung function in older adults: The English longitudinal study of ageing. Prev med. 2018;106:145-9.
5. Vaz Fragoso CA, Beavers DP, Anton SD, Liu CK, McDermott MM, Newman AB, et al. Effect of structured physical activity on respiratory outcomes in sedentary elderly adults with mobility limitations. J Am Geriatr Soc. 2016;64(3):501-9.
6. de Rezende LFM, Rey-López JP, Matsudo VKR, do Carmo Luiz O. Sedentary behavior and health outcomes among older adults: a systematic review. BMC public health. 2014;14(1):333.

7. de Assis Bastosa VdG, Gomesa EB, Valdugaa R, de Toledo Nóbregab O, de Azevedo Carvalhoa G. A comparative study of thoracic kyphosis angles and respiratory muscle strength of elderly women. Geriatr gerontol and aging. 2017; 11(3):133-37
8. Singer KP, Edmondston SJ, Day RE, Breidahl WH. Computer-assisted curvature assessment and Cobb angle determination of the thoracic kyphosis: an in vivo and in vitro comparison. Spine. 1994;19(12):1381-4.
9. Antonelli-Incalzi R, Pedone C, Cesari M, Di Iorio A, Bandinelli S, Ferrucci L. Relationship between the occiput-wall distance and physical performance in the elderly: a cross sectional study. Aging Clin Exp Res. 2007;19(3):207-12.
10. Smith MD, Russell A, Hodges PW. Disorders of breathing and continence have a stronger association with back pain than obesity and physical activity. Aust J Physiother. 2006;52(1):11-6.
11. Tunçay SU, Yeldan İ. Is Physical Inactivity Associated With Musculoskeletal Disorders?. Ağrı. 2013;25(4):147-55.
12. Kaneko H. Association of respiratory function with physical performance, physical activity, and sedentary behavior in older adults. J Phys Ther Sci. 2020;32(2):92-7.
13. Hyatt RE, Scanlon PD, Nakamura M. Interpretation of pulmonary function tests: Lippincott Williams & Wilkins; 2014.
14. Ayvat E, Kilinc M, Kirdi N. The Turkish version of the Physical Activity Scale for the Elderly (PASE): its cultural adaptation, validation, and reliability. Turk J Med Sci. 2017;47(3):908-15.
15. Lewis JS, Valentine RE. Clinical measurement of the thoracic kyphosis. A study of the intra-rater reliability in subjects with and without shoulder pain. BMC Musculoskelet Disord. 2010;11(1):1-7.
16. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behav Res Methods. 2009;41(4):1149-60.
17. Faul F, Erdfelder E, Lang A-G, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91.
18. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol. 1993;46(2):153-62.
19. Enright PL, Lebowitz MD, Cockroft DW. Physiologic measures: pulmonary function tests. Am J Respir Crit Care Med. 2012.
20. Ranu H, Wilde M, Madden B. Pulmonary function tests. Ulster Med J. 2011;80(2):84.
21. Streiner DL, Norman GR, Cairney J. Health measurement scales: a practical guide to their development and use: Oxford University Press, USA; 2015.
22. Lorbergs AL, O'Connor GT, Zhou Y, Travison TG, Kiel DP, Cupples LA, et al. Severity of kyphosis and decline in lung function: the Framingham study. J Gerontol A Biol Sci Med Sci. 2017;72(5):689-94.
23. Haynes JM. Pulmonary function test quality in the elderly: a comparison with younger adults. Respir Care; 2014;59(1):16-21.
24. Berglund DJ, Abbey DE, Lebowitz MD, Knutsen SF, Mc Donnell WF. Respiratory symptoms and pulmonary function in an elderly nonsmoking population. Chest. 1999;115(1):49-59.
25. Wannamethee SG, Shaper AG, Whincup PH. Body fat distribution, body composition, and respiratory function in elderly men. Am J Clin Nutr. 2005;82(5):996-1003.
26. Ab Rahman NNA, Singh DKA, Lee R. Correlation between thoracolumbar curvatures and respiratory function in older adults. Clin Interv Aging. 2017;12(1):523.
27. Di Bari M, Chiarlone M, Matteuzzi D, Zacchei S, Pozzi C, Bellia V, et al. Thoracic kyphosis and ventilatory dysfunction in unselected older persons: an epidemiological study in Dicomano, Italy. J Am Geriatr Soc. 2004;52(6):909-15.
28. Pereira FD, Batista WO, Fuly PdSC, Alves Junior EdD, Silva EBd. Physical activity and respiratory muscle strength in elderly: a systematic review. Fisioterapia em Movimento. 2014;27(1):129-39.
29. Aksović N, Bjelica B, Joksimović M, Skrypchenko I, Filipović S, Milanović F, et al. Effects of aerobic physical activity to cardio-respiratory fitness of the elderly population: systematic overview. Phys Educ Sport Pedagogy. 2020;24(5):208-18.