Original article

Association of pulmonary function with functional capacity among middle-aged women

Associação da função pulmonar com capacidade funcional em mulheres de meia idade

Hina Vaish[1]
Digvijay Sharma[2]

[1]Corresponding author. Chhatrapati Shahu Ji Maharaj University (Kanpur). Uttar Pradesh, India. hina22vaish@gmail.com, hinavaish@csjmu.ac.in
[2]Chhatrapati Shahu Ji Maharaj University (Kanpur). Uttar Pradesh, India.

ABSTRACT | INTRODUCTION: Age-related decline in pulmonary function and functional capacity is seen in adults. The menopausal process leads to a decline in pulmonary function and functional capacity which is essential in maintaining independence in daily life. **OBJECTIVE:** The present study aimed to explore the association of pulmonary function with functional capacity among middle-aged women. **METHODS:** One hundred and eight female participants aged 40–55 years were included in this cross-sectional study; depending on their menstrual history participants were classified as premenopausal and postmenopausal. After initial screening and assessment, six-minute walk test (6MWT) and pulmonary function (FEV_1, FVC, FEV_1/FVC) were recorded as per standardised guidelines. The mean and standard deviation for all continuous variables were calculated. Correlations were estimated using Pearson's coefficient of correlation. A comparison of premenopausal and postmenopausal groups was done by independent t-test. A two-tailed p-value < 0.05 was considered statistically significant. **RESULTS:** There were significant differences in values of six-minute walk distance (6MWD) and pulmonary function values of pre and postmenopausal women ($p < 0.05$). The Pearson coefficient of correlation showed significant association of FEV_1, FVC and FEV_1/FVC with 6MWD among middle-aged women. There was fair positive correlation of FEV_1 ($r = 0.391$, $p = 0.002$) and FEV_1/FVC ($r = 0.395$, $p = 0.002$) with 6MWD among postmenopausal women. **CONCLUSION:** There exists a fair positive correlation of pulmonary function with 6MWD among middle-aged women particularly postmenopausal women. Early screening of respiratory health and functional capacity should be initiated for middle-aged women as a preventive strategy.

KEYWORDS: Postmenopause. Respiratory Function Tests. Six-minute Walk Distance. Spirometry.

RESUMO | INTRODUÇÃO: O declínio da função pulmonar e da capacidade funcional relacionado à idade é observado em adultos. O processo menopausal leva ao declínio da capacidade pulmonar e funcional, essencial para a manutenção da independência na vida diária. **OBJETIVO:** O presente estudo teve como objetivo explorar a associação da função pulmonar com a capacidade funcional em mulheres de meia idade. **MÉTODOS:** Cento e oito participantes do sexo feminino com idade entre 40 e 55 anos foram incluídas neste estudo transversal; dependendo da história menstrual, as participantes foram classificadas como pré-menopausa e pós-menopausa. Após triagem e avaliação inicial, teste de caminhada de seis minutos (TC6M) e função pulmonar (VEF_1, CVF, VEF_1/CVF) foram registrados de acordo com diretrizes padronizadas. Foram calculados média e desvio padrão para todas as variáveis contínuas. As correlações foram estimadas pelo coeficiente de correlação de Pearson. A comparação do grupo pré-menopausa e pós-menopausa foi feita por teste t independente. Um valor de p bicaudal < 0,05 foi considerado estatisticamente significativo. **RESULTADOS:** Houve diferenças significativas nos valores da distância caminhada de seis minutos (DC6M) e nos valores da função pulmonar de mulheres pré e pós-menopausa ($p < 0,05$). O coeficiente de correlação de Pearson mostrou associação significativa de VEF_1, CVF e VEF_1/CVF com a DC6M entre mulheres de meia idade. Houve correlação positive moderada do VEF_1 ($r = 0,391$, $p = 0,002$) e VEF_1/CVF ($r = 0,395$, $p = 0,002$) com a DC6M entre mulheres na pós-menopausa. **CONCLUSÃO:** Existe correlação positiva moderada da função pulmonar com a DC6M entre mulheres de meia idade, particularmente mulheres na pós-menopausa. O rastreio precoce da saúde respiratória e da capacidade funcional deve ser iniciado nas mulheres de meia idade como estratégia preventiva.

PALAVRAS-CHAVE: Pós-Menopausa. Testes de Função Respiratória. Distância Caminhada de Seis Minutos. Espirometria.

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1. Introduction

Pulmonary function and functional capacity are essential in maintaining a good quality of life of an individual as one ages. Age-related decline in pulmonary function and functional capacity is seen in adults. Functional capacity is the capacity of individual to perform activities of sub maximal level, which is assessed by variety of tests and one of the most useful tests to measure functional capacity is six-minute walk test (6MWT).[1] Assessment of functional capacity enables the design of preventive strategies and combats the beginning of physical frailty that takes place as age advances.[2]

Moreover, the normal function of the lung changes minimally from 20 to 35 years of age but thereafter starts declining gradually due to various anatomical and physiological changes with aging.[3] Women are more susceptible to developing chronic obstructive pulmonary disease (COPD) than men, especially among never-smokers, and it is speculated that these sex differences may arise partly from distinct sex hormone patterns during life.[4]

There is an influence of gender on functional capacity.[5] The decline in physiological parameters is also attributed to menopause in women. There are physiological changes due to menopause that could contribute directly to limitations in physical function.[6,7] It has been expected that by age the of 45, within a timeframe of the menopause transition, up to 10–15% of women might be classified as disabled.[8]

There is some evidence from previous literature of more physical limitation in the postmenopausal women in comparison to the premenopausal women.[6,7] It has been reported by authors that postmenopausal women have diminished muscle power, strength, and mass.[7] Few authors reported that the menopausal status is also associated with low lung function.[9-11]

There has been reports of the association of pulmonary function with functional capacity among healthy adults as well as pathological conditions.[2,12] The menopausal process leads to a decline in pulmonary function and functional capacity which is essential in maintaining independence in daily life. The lack of independence may have significant public health implications owing to the adverse impact on the quality of life of women as they age. Maintaining functional status is an important part of active aging, as it enables independent living.

There is scarcity of literature regarding the association of pulmonary function and functional capacity in women. Thus, the present study aimed to explore the association of pulmonary function with functional capacity among middle-aged women. The secondary objective was to study the correlation of pulmonary function and functional capacity with anthropometric variables among middle-aged women.

2. Material and methods

2.1 Study design

This is a cross-sectional study.

2.2 Ethical statement

This study has obtained ethical clearance from Institutional Ethical Committee. The study was performed under Indian Council of Medical Research (2017) National Ethical Guidelines for biomedical and health research involving human participants and the ethical principles for medical research involving human subjects stated in the Declaration of Helsinki (revised 2013).

2.3 Eligibility criteria

Asymptomatic female participants aged 40–55 years with stable vitals were included; depending on the menstrual history participants were classified as premenopausal and postmenopausal. The menstrual bleeding pattern was classified based on a series of questions.[6,11]

Participants with absence of any acute disease during the six weeks preceding the study were included. Participants with any health problem or use of medication affecting the different systems of the body, as well as those that may impact physical

exercise; the use of walking aids, sensory deficits, a blood pressure of greater than 139/89 mm Hg, body mass index (BMI) values below 18.5 kg/m² or above 29.9 kg/m², a resting heart rate of 100 bpm or higher, smoking history (past or present), any surgeries within the past year, females who have delivered a baby within the past two years, those who have undergone a double oophorectomy or hysterectomy, women with the use of hormone replacement therapy, involved in sports or athletic activity, were excluded.

2.4 Sample size estimation

The sample size for this study was calculated by using the G power software version 3.1.97, considering the coefficient of determination and level of significance was set as 5% at 80% power of the study and considering the correlation coefficient (r) of 0.28 for spirometry variable from a previous study among women.[1] The minimum required sample size was 97. Considering 10 percent dropout, the required sample size was 107. We recruited 108 participants by purposive sampling method. The sample was selected from among individuals accompanying patients in the OPD, staff and those visiting the institute and from nearby community dwellings.

2.5 Study participants

Participants were recruited from October 2023 to January 2024. Prior to the intervention, all participants were asked to sign the informed consent. Confidentiality of participants was ensured.

2.6 Procedure

Body weight (in kg) was measured with a weighing machine. Body height (in meters) was recorded and body mass index (BMI = weight/height^2) was calculated.

Measurement of force expiratory volume in one second (FEV_1), force vital capacity (FVC), ratio of FEV_1 and FVC (FEV_1/FVC), and distance covered during(6MWT) known as six-minute walk distance (6MWD) was recorded.

Pulmonary function test was measured by using RMS Helios 401- computerized spirometer as per standardized guidelines.[13] Before performing the test, all the participants were allowed to take a rest period to prevent measurement error. Participants performed the test three times to obtain the best value.

The 6MWT was executed following a standardized protocol[14,15] in an uninterrupted 30-meter indoor corridor marked at 1-meter intervals. Standard verbal encouragement was provided every minute in the local language.[14] All participants undertook the 6MWT for the first time without a preliminary warm-up. Prior to the test, participants rested in a chair positioned near the starting line for at least 10 minutes. During this rest period, measurements were taken for a rate of perceived exertion (RPE) using the Modified Borg Rating of Perceived Exertion, heart rate, oxyhemoglobin saturation, and both systolic and diastolic blood pressures. Participants were instructed to walk as far as possible along the corridor at their own pace for six minutes. They were permitted to stop if they experienced dizziness, dyspnoea, leg cramps, or chest pain, though they were encouraged to resume walking as soon as feasible. After the 6MWT, each participant's heart rate, systolic and diastolic blood pressures, oxygen saturation, and RPE were recorded, along with the total distance covered during the six-minute period (6MWD).

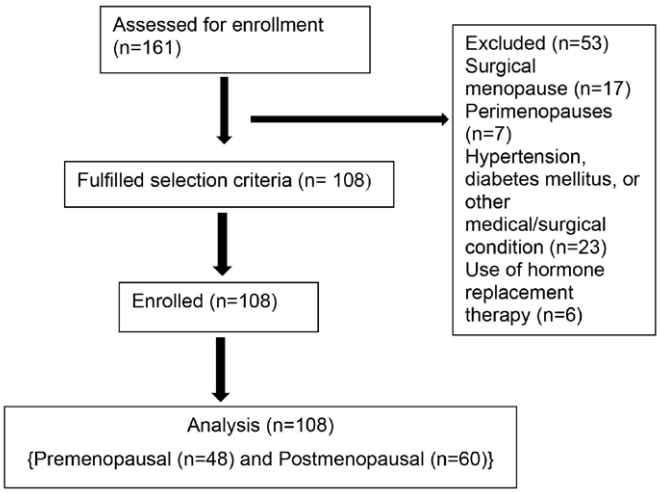
2.7 Statistical analysis

Statistical analyses were performed using SPSS software, version 16 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). Data was normally distributed and presented as the mean and standard deviation for all continuous variables. Correlations were estimated using Pearson correlation analysis with cutoff points: 0 - 0.3: poor correlation, 0.3 - 0.5: fair correlation; 0.6- 0.8: moderately strong correlation, at least 0.8: very strong correlation and 1: perfect correlation.[16,17] Comparison of the premenopausal and postmenopausal groups was done by independent t-test. The effect size for pulmonary function and functional capacity was also calculated. A two-tailed p-value < 0.05 was considered statistically significant.

3. Results

The sample of 108 female participants was distributed as follows: 60 women were postmenopausal and 48 women were premenopausal. The study flowchart is shown in Figure 1. All the participants completed the test and there were no dropouts.

Figure 1. Study flowchart



Source: the authors (2024).

The characteristics of the participants are shown in Table 1. The mean age of the total participants (n=108) was 49.56 ± 2.62 years. There were no significant differences among height, weight and BMI of the participants.

Table 1. Baseline data of the participants

	Total population (n=108) MEAN ± SD	Premenopausal women (n=48) MEAN ± SD	Postmenopausal women (n=60) MEAN ± SD	P
Age (years)	49.56 ± 2.62	48.85 ± 2.09	50.12 ± 2.86	0.012*
Age at menopause (years)	----------	----------	48.12 ± 2.78 years	----------
Height (m)	1.55 ± 0.83	1.55 ± 0.80	1.55 ± 0.84	0.975
Weight (kg)	59.95 ± 10.27	60.27 ± 10.73	59.69 ± 9.97	0.772
BMI (kg/m^2)	24.34 ± 3.17	24.44 ± 3.17	24.26 ± 3.2	0.782

SD = standard deviation; BMI = body mass index
*Significant at p< 0.05 (2-tailed).
Source: the authors (2024).

None of the participants stopped during the 6MWT. The mean ± SD 6MWD was 473.8 ± 56.76 m. The 6MWD was greater in the premenopausal group than in the postmenopausal group (p = 0.013) shown in Table 2. Also, the premenopausal women had greater values of FEV_1, FVC and FEV_1/FVC in comparison to postmenopausal group as shown in table 2. The effect sizes were calculated by Hedges g for FEV_1,(1.29), FVC (0.70), FEV_1/FVC (1.05) and 6MWD (0.49).

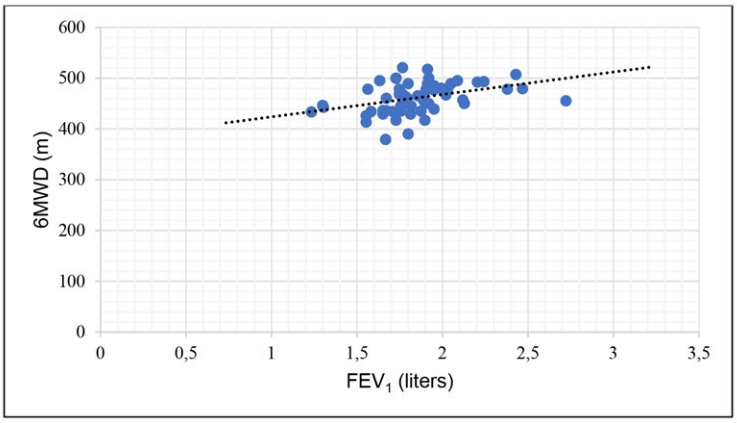
Table 2. Pulmonary function and six-minute walk test results of the participants

	Total population (n=108) MEAN ± SD	Premenopausal women (n=48) MEAN ± SD	Postmenopausal women (n=60) MEAN ± SD	P
FEV_1 (liters)	2.00 ± 0.29	2.18 ± 0.23	1.86 ± 0.26	0.0001*
FVC (liters)	2.54 ± 0.36	2.67 ± 0.25	2.43 ± 0.4	0.0001*
FEV_1/FVC(%)	78.94± 5.63	81.93 ± 3.36	76.67 ± 6.01	0.0001*
6MWD (m)	473.8 ± 56.76	488.87 ± 76.06	461.73 ± 30.00	0.013*

*Significant at $p < 0.05$ (2-tailed).
FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity; 6MWD = 6-minute walk distance; SD = standard deviation.
Source: the authors (2024).

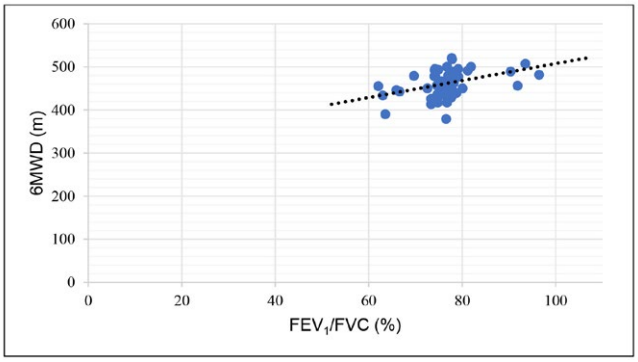
There was fair positive correlation of FEV_1 with 6MWD among middle aged women. The correlations are described in Table 3.

Figure 2. Correlation of FEV_1 with 6MWD



6MWD = 6-minute walk distance; FEV_1 = forced expiratory volume in 1 second
Source: the authors (2024).

Figure 3. Correlation of FEV_1/FVC ratio with 6MWD



6MWD = 6-minute walk distance; FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity
Source: the authors (2024).

Anthropometric characteristics were also correlated with pulmonary function and 6MWD. The correlations are shown in Table 3. The age at menopause has no correlation with FEV_1 (r = - 0.106), FVC (r = 0.062) and 6MWD (r =- 0.120). There was poor correlation of FEV_1/FVC (r = -0.296, p < 0.05) with age at menopause.

Table 3. Correlation of pulmonary function and functional capacity (6MWD)

Variable	Total population (N=108)		Premenopausal women (n=48)		Postmenopausal women (n=60)	
	r	p	r	p	r	p
6MWD (m)						
FEV_1 (liters)	0.339	0.0001*	0.233	0.110	0.391	0.002*
FVC (liters)	0.235	0.01*	0.259	0.075	0.155	0.238
FEV_1/FVC (%)	0.236	0.014*	0.014	0.927	0.395	0.002*
Age(years)	-0.190	0.048*	-0.056	0.707	-0.336	0.009*
Height (m)	0.215	0.025*	0.293	0.044*	0.155	0.237
Weight (kg)	-0.28	0.776	-0.067	0.651	0.25	0.848
BMI (kg/m^2)	-0.235	0.01*	-0.357	0.013*	-0.103	0.434
FEV_1 (liters)						
Age(years)	-0.220	0.022*	-0.046	0.754	-0.137	0.295
Height (m)	0.683	0.0001*	0.774	0.0001*	0.850	0.0001*
Weight (kg)	0.512	0.0001*	0.601	0.0001*	0.600	0.0001*
BMI (kg/m^2)	0.136	0.162	0.251	0.086	0.75	0.569
FVC (liters)						
Age(years)	-0.048	0.623	-0.041	0.783	0.062	0.624
Height (m)	0.808	0.0001*	0.734	0.0001*	0.939	0.0001*
Weight (kg)	0.521	0.0001*	0.543	0.0001*	0.572	0.0001*
BMI (kg/m^2)	0.038	0.693	0.187	0.203	-0.92	0.695
FEV_1/FVC (%)						
Age(years)	-0.343	0.0001*	-0.024	0.871	-0.354	0.006*
Height (m)	-0.061	0.530	0.383	0.007*	-0.270	0.37
Weight (kg)	0.99	0.306	0.362	0.011*	-0.27	0.840
BMI (kg/m^2)	0.199	0.039	0.245	0.094	0.223	0.087

*Significant at p < 0.05 (2-tailed)
6MWD = 6-min walk distance; FVC = forced vital capacity; FEV_1 = forced expiratory volume in 1 second, r = correlation coefficient
Source: the authors (2024).

4. Discussion

To our knowledge, this is the first study to evaluate the association of functional capacity with pulmonary function in a cohort of middle-aged women. There were two important findings. First, there was a significant difference in 6MWD and pulmonary function in premenopausal and postmenopausal groups. Secondly, there is an association between pulmonary function and functional capacity among middle-aged women; the association was also there among postmenopausal women. Furthermore, the distance covered by participants in this study was shorter than the distances reported by researchers for Indian females.[2,18]

4.1 Influence of menopause on 6MWD

Menopause significantly influenced the 6MWD in participants, which agrees with reports available by researchers from previous studies.[19] The correlation of age at menopause was also studied with 6MWD. The menopause is related with a natural decline in estrogen that increases visceral fat mass, and decreases bone mass density, muscle mass, and strength.[7] The decline in muscle mass and strength directly influences the 6MWD. Also, age is associated with a decline in lower limb strength and power.[20] Researchers have also provided evidence demonstrating that menopause is linked to physical performance in middle-aged women, with a stronger association observed with the musculoskeletal system compared to other body systems, such as the cardiovascular and vestibular systems.[21,22]

4.2 Influence of menopause on pulmonary function

The pulmonary function was also significantly less in postmenopausal women in agreement with previous literature.[9-11] Systemic inflammation, which is linked with menopausal hypoestrogenism and impaired lung function.[11] Osteoporosis is associated with reduced height of the thoracic vertebrae which places the diaphragm in a suboptimal position.[23]

There was a mild negative correlation of FEV_1/FVC with age at menopause. There is evidence that a decline in pulmonary function among postmenopausal women in India tend to develop obstructive pattern of ventilatory limitation.[9]

4.3 Association of pulmonary function with functional capacity

The correlations of spirometry values had a significant association with functional capacity in the present study. There has been a positive correlation between lung function and the 6MWT as found in reports from previous studies including female participants.[1,2,24] This indicates that as lung function decreases, it impacts functional capacity. Lung function has been proposed as an independent predictor of 6MWD in healthy participants, as well as pathological states.[1,24,25] The significant positive association of FEV_1 and FEV_1/FVC with 6MWD was also there among postmenopausal women indicating that the decline in pulmonary function is associated with a decline in function capacity after menopause.

4.4 Association of anthropometric characteristics with 6MWD and pulmonary function

Age was found to be significantly negatively associated with 6MWD in total population as well as postmenopausal group. The shorter distance walked as age increases can be explained by decreases in muscle mass, muscle strength, and maximum oxygen consumption as one age.[1,2]

Height positively correlated with 6MWD in the total population and premenopausal group; investigators have attributed the association between height and 6MWD to the greater leg length that generally accompanies increased height; this results in longer strides and a more efficient gait.[15]

BMI had significant negative correlations with 6MWD in the total population and premenopausal group as obesity increases, it elevates the workload required for any given amount of exercise, thereby impacting the distance walked.

In the present study, there was a significant association of age with FEV_1 and FEV_1/FVC. Height and weight, also showed association with pulmonary parameters. Age, height, and weight has been proposed as strong predictors of lung function among South Asian individuals.[26]

4.5 Limitations

The study had a few limitations: non probability sample was taken though this has been a procedure of sample collection in previous research reports.[2,18,19] But we had stringent inclusion and exclusion criteria. This study presents limitations related to the non-identification of other pulmonary parameters like diffusion capacity and total lung capacity. Other factors influencing functional capacity such as motivation factors were also not considered. Also, induced/surgical menopausal women were not included. Hence, we proposed that future multicentre studies should be conducted including surgical menopausal women.

5. Conclusion

There exists a significant positive correlation of pulmonary function with 6MWD among middle-aged women particularly postmenopausal women. Early screening of respiratory health and functional capacity should be initiated for middle-aged women as a preventive strategy.

Authors contributions

The authors declare that they have made sufficient contributions to the work in terms of the conception or design of the research; the acquisition, analysis or interpretation of data for the work; and the writing or critical review for relevant intellectual content. All authors approved the final version to be published and agreed to take public responsability for all aspects of the work.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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