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Dyspnoea Severity, Functional Capacity, and Respiratory Muscle Strength in Healthy Aging

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Abstract

Dyspnea is frequently observed as people age, little is known about its frequency and functional effects in healthy people without a diagnosis of cardiovascular disease. This study investigated the links between functional capacity and the degree of dyspnea, functional limitations, and respiratory muscle strength in healthy aging. 62 healthy individuals were enrolled in this study, consisting 31 young adults (18–28 years old) and 31 elderly persons (60–77 years old). The Borg CR10 scale and the modified Medical Research Council scale were used to measure the severity of dyspnea both at rest and during a standardized 6-minute walk test (6MWT). The Pulmonary Functional Status and dyspnea Questionnaire–Modified (PFSDQ-M) was used to assess functional limitations associated with dyspnea. The 6MWT distance was used to measure functional exercise capacity, and maximal inspiratory and expiratory pressures (MIP and MEP) were used to assess respiratory muscle strength. When compared to younger adults, older adults had significantly higher PFSDQ-M scores, lower respiratory muscle strength, decreased 6MWT performance, and more severe dyspnea both at rest and after exertion (all $p < 0.001$). Functional limitation scores were favorably correlated with dyspnea severity and age, whereas dyspnea severity was inversely correlated with respiratory muscle strength and functional capacity. These findings indicate that dyspnea may be an early indicator of respiratory functional decline in healthy aging, since detectable respiratory and functional limitations exist even in healthy older persons.

Keywords: Dyspnoea severity; Healthy aging; Functional capacity; Respiratory muscle strength; Six-minute walk test.

Background

Dyspnoea is a debilitating symptom that impact quality of life, exercise tolerance and mortality [1]. The world's population is aging at an accelerated rate; according to the World Health Organization, this number was one billion in 2019 and is predicted to reach 2.1 billion by 2050 [2]. The number of people over 65 in Australia increased by 67% between 1980 and 2000, indicating that the country's population is aging. One Around 12% of Australians are over 65 at the moment, and by 2031, that number is predicted to increase to 22% [3]. Therefore, it is still necessary to determine the physiological impacts of aging. This information is necessary to enable the use of suitable actions to support the preservation of these people's health and quality of life.

As people age, their physiological systems, including the respiratory system are affected and their lung elasticity decreases, their respiratory muscles weaken, and their thoracic structure changes [4,5]. Sarcopenia, a condition in which the body gradually loses skeletal muscle mass, is a common cause of the weakening of the inspiratory muscles, which reduces the effectiveness of respiratory mechanics [6]. Respiratory mechanics are negatively impacted by improper head posture, which reduces their effectiveness [7]. Due to skeletal muscle weakness, reduced elastic recoil, and compromised mucociliary clearance, lung function gradually deteriorates with age, resulting in common respiratory symptoms including cough and dyspnoea [8]. The respiratory muscle (RM) function, which is crucial for physical performance and quality of life in older adults, is deteriorating due to aging. RM strength, which can be predicted by age, is particularly important for walking performance in males, and inspiratory muscle endurance (IME) is a significant factor for all participants.

During exercise, older men generated more expiratory muscle pressure as compared to younger men but the respiratory neuromuscular activation pattern in diaphragm, sternocleidomastoid, intercostal muscle and rectus abdominis muscle was same and there was no difference in EMG response. Younger men showed shallow breathing compared to older men. The higher expiratory muscle pressure in older men might be a compensatory mechanism to counteract the aging related airway resistance [9]. Future studies should evaluate, weather high intensity exercise develop respiratory muscles fatigue in older men.

The intensity of exertional dyspnoea is higher in older women as compared to older men because older women have higher degree of mechanical ventilator constrain (work of breathing and expiratory flow limitation) during exercise at absolute intensity or minute ventilation which lead to higher intensity of dyspnoea. During moderate-intensity exercise, mechanical ventilatory limitation had no discernible effect on the sensation of dyspnoea in older men and women [10]. Understanding the respiratory restrictions on exercise in healthy ageing is essential for fostering health and functional independence, especially in light of the world's ageing population.

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In spite of the advancements in the treatment of several cardiopulmonary disorders, millions of patients are severely disabled by dyspnoea. Research on the mechanisms of dyspnoea has advanced significantly since the original ATS consensus statement was published in 1999, but the precise treatment of dyspnoea has not advanced much [11]. The evaluation and treatment of dyspnoea is essential in understanding respiratory limitations in healthy ageing. Key techniques include pulmonary function test, work of breathing, pressure time product and Borg Dyspnoea Scale are widely used to assess breathlessness during physical activity [12-14].

This article discuss critical issues of how age-related physiological changes affect respiratory function during exercise, a concern that is becoming more and more pertinent in our aging population. The connection between respiratory neuro-mechanical coupling and dyspnoea is fairly well defined in COPD, but it is unclear in healthy aging, as well as in males and females. The mismatch between respiratory neural drive and the mechanical response of respiratory muscles in COPD results in neuro-mechanical uncoupling, which is fundamental to the origin of dyspnoea during physical activity [15]. This research can contribute to understanding of dyspnoea faced by older individuals, as it notes that inspiratory muscle strength and endurance decline with age, resulting in increased mechanical work of breathing and higher oxygen consumption during exercise.

Aim

To explore the occurrence of dyspnoea in healthy aging and its effect on physical function. To examine exercise related dyspnoea and respiratory muscle strength in healthy aging.

Research Objectives

To evaluate the severity of dyspnoea in healthy aging and its related functional limitations, and also to assess the respiratory muscle strength, and compare dyspnoea characteristics between young and older adults, as well as examine the respiratory functional decline in healthy older adults.

Methodology

Study Design

A cross-sectional comparative study was carried out to examine the respiratory muscle strength, functional exercise capacity, and dyspnea severity in young, healthy people and older persons. In order to investigate age-related changes and the connections between respiratory muscle performance, functional restriction, and dyspnea, the study compared two age-based groups.

Study Setting

Data were collected in a controlled clinical and field environment suitable for conducting respiratory muscle testing and the six-minute walk test (6MWT) in accordance with standardized guidelines.

Study Population

A total of 62 healthy participants were enrolled and divided into two groups: Young adults including 31 participants having age between 18–28 years and Older adults also include 31 participants having age between 60–77 years. Participants were recruited through voluntary participation using convenience sampling.

Inclusion Criteria

Apparently healthy individuals, No history of diagnosed cardiovascular, respiratory, or neuromuscular disease and ability to perform the 6-minute walk test independently

Exclusion Criteria

History of chronic obstructive pulmonary disease, asthma, interstitial lung disease, or heart disease, Neurological or musculoskeletal conditions affecting mobility, Acute illness at the time of assessment and Inability to perform respiratory pressure testing or the 6MWT

Sample Size

A total sample of 62 participants (31 per group) was included. This sample size was considered adequate for detecting between-group differences in dyspnoea scores, respiratory muscle strength, and functional capacity based on prior similar comparative studies in healthy aging populations.

Study Measures

Dyspnoea Assessment

Two validated scales were used to measure the severity of dyspnea. Baseline dyspnea during everyday activities was assessed using the Modified Medical Research Council (mMRC) Dyspnoea Scale, which has a score range of 0 to 4 [16] . Higher scores indicate more dyspnea. Additionally, perceived dyspnea was measured using the Modified Borg CR10 Dyspnoea Scale [17] before the six-minute walk test, throughout the test, and right after the test was finished.

Functional Limitation

The Pulmonary Functional Status and Dyspnea Questionnaire – Modified (PFSDQ-M) was used to assess functional limitations associated with fatigue and dyspnea [18]. This questionnaire evaluates the degree of activity limitation, weariness related to daily living activities, and dyspnea during those activities. Greater functional impairment is indicated by higher PFSDQ-M scores.

Functional Exercise Capacity

The Six-Minute Walk Test (6MWT) was used to assess functional exercise ability in accordance with American Thoracic Society (ATS) recommendations [19]. The participants were given a standardized corridor to walk as far as they could in six minutes, and the total distance they covered (measured in meters) was noted. Before and right after the test, pulse oximetry was used to determine peripheral oxygen saturation (SpO_2).

Respiratory Muscle Strength

Respiratory muscle strength was assessed using: Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP). Measurements were obtained using a calibrated respiratory pressure manometer. Participants performed maximal inspiratory and expiratory efforts according to standard procedures, and the best of at least three reproducible trials was recorded.

Study Procedure

Demographic information and baseline clinical data were documented following informed permission. The Borg scale for dyspnea and resting SpO_2 were recorded. After that, participants finished the PFSDQ-M questionnaire and the mMRC scale. To prevent the effects of exercise-induced exhaustion, respiratory muscle strength (MIP and MEP) was assessed before the 6MWT. After that, the 6MWT was carried out in compliance with ATS regulations. Together with post-test SpO_2 levels, Borg dyspnea scores were noted both during and right after the test.

Ethical Considerations

The study was carried out in compliance with the Declaration of Helsinki's tenets. All participants provided written informed consent before any data was collected. Anonymity and confidentiality of study participants were preserved. Participants were made aware that they might leave at any moment and would not be penalized.

Statistics

SPSS software was used to evaluate the data. For every variable, descriptive statistics (mean ± standard deviation) were computed, and before inferential testing, normality was evaluated. The Mann-Whitney U test was used to compare groups. The associations between age, respiratory muscle strength (MIP and MEP), PFSDQ-M scores, 6MWT distance, and dyspnea severity (mMRC and Borg ratings) were investigated using Spearman's rank correlation coefficient. Statistical significance was defined as a p-value of less than 0.05.

Data Analysis

A total of 62 participants were included in which 31 were young adults between the age of 18 to 28 and 31 were older adults between the ages of 60 to 77 years. The burden of dyspnea was higher in older adults at the baseline and during physical activity. Also, the mMRC scores were greater in older adults than younger adults. Furthermore, the Borg Dyspnea scale rating was considerably greater in older population throughout the 6-minute walk test ($p<0.001$), showed that they experienced more dyspnea during exercise.

Table 1: *The statistics of descriptive and group comparisons between older and young adults.*

Variable	Young Adults (n = 31) Mean ± SD	Older Adults (n = 31) Mean ± SD	p-value
mMRC score	0.2 ± 0.4	1.1 ± 0.7	<0.001
Borg (during 6MWT)	1.0 ± 0.5	2.1 ± 0.7	<0.001
Borg (post 6MWT)	1.1 ± 0.6	2.4 ± 0.8	<0.001
6MWT distance (m)	650 ± 45	480 ± 60	<0.001
PFSDQ-M total dyspnea	2.5 ± 1.2	6.8 ± 2.1	<0.001
PFSDQ-M total fatigue	1.9 ± 1.0	6.1 ± 2.3	<0.001
PFSDQ-M total functional limitation	3.0 ± 1.4	8.2 ± 2.5	<0.001
MIP (cmH_2O)	95 ± 12	65 ± 14	<0.001
MEP (cmH_2O)	120 ± 20	85 ± 18	<0.001
SpO_2 pre-6MWT (%)	98 ± 1	96 ± 2	0.01
SpO_2 post-6MWT (%)	97 ± 1	95 ± 2	0.02

The functional capacity of both groups were different from each other. The older adults indicated greater functional limits on all PFSDQ-M scales, including activity restriction, fatigue, and dyspnea ($p<0.001$), and during 6-minute walk test, covered short distance. These findings evaluate that age related decline in ventilatory efficiency are associated with early functional limitations. In the older adults the strength of respiratory muscles decreased. The older adults showed the decreased maximum inspiratory pressure MIP and maximum expiratory pressure values ($p<0.001$), as compared to younger adults, indicating that their respiratory muscles are not functioning properly. The decline remained clinically minor, the older adults also indicate the lower oxygen saturation ($p<0.001$) after 6-minute walk test.

Correlation study showed strong relationships between age and specific respiratory markers. Age was positively correlated with mMRC, Borg (before and after exercise), and PFSDQ-M scores ($p < 0.01$). On the other hand, age and 6MWT distance, MIP, and MEP showed a negative connection ($p < 0.01$). More severe dyspnea was also associated with weaker respiratory muscles and poorer functional efficiency. These findings imply that early functional respiratory decline may be seen even in otherwise healthy older adults.

Table 2: *The correlation of spearman test for dyspnea, functional capacity, and respiratory muscle strength.*

Variable	Age	Borg Post	6MWT	MIP	MEP	PFSDQ-M Total
Age	—	0.62 (p < 0.001)	−0.68 (p < 0.001)	−0.55 (p < 0.001)	−0.48 (p < 0.001)	0.72 (p < 0.001)
Borg Post	0.62 (p < 0.001)	—	−0.59 (p < 0.001)	−0.44 (p = 0.002)	−0.40 (p = 0.005)	0.65 (p < 0.001)
6MWT	−0.68 (p < 0.001)	−0.59 (p < 0.001)	—	0.52 (p < 0.001)	0.48 (p < 0.001)	−0.70 (p < 0.001)
MIP	−0.55 (p < 0.001)	−0.44 (p = 0.002)	0.52 (p < 0.001)	—	0.61 (p < 0.001)	−0.50 (p < 0.001)
MEP	−0.48 (p < 0.001)	−0.40 (p = 0.005)	0.48 (p < 0.001)	0.61 (p < 0.001)	—	−0.46 (p < 0.001)
PFSDQ-M Total	0.72 (p < 0.001)	0.65 (p < 0.001)	−0.70 (p < 0.001)	−0.50 (p < 0.001)	−0.46 (p < 0.001)	—

Discussion

The study findings clearly demonstrated that there are significant age-related changes in respiratory musculature performance, dyspnea severity, and decline in exercise tolerance. All these factors suggest that these changes can help in the early detection of respiratory functional decline in the healthy aging process. It has been observed that the elderly population exhibits significantly higher indications of dyspnea during physical activities and even at rest, based on higher scores of mMRC and Borg scale. These results are in line with the previous studies that manifest that respiratory effort increases with the advancement in age. Multiple factors are involved in the significant increase in respiratory efforts. It includes altered neuromuscular respiratory drive, alteration in the thoracic compliance, and a decrease in elastic recoil [20].

The older group's higher mMRC and Borg scores are in line with other research that found that decreased lung elastic recoil, increased chest wall stiffness, and changed ventilatory mechanics all contribute to an increased sense of dyspnea as people age. According to McConnell and Romer, age-related declines in inspiratory muscle power make breathing more difficult and increase the likelihood of experiencing dyspnea when exerting oneself. Similar to this, another study showed that older persons have a larger ventilatory demand for a given workload, which could account for the higher levels of dyspnea observed during the current study's 6MWT [21].

The 6MWT indicated a significant decline in the respiratory functional capacity in elderly persons. These results are consistent with the sarcopenia-related constraints and lower aerobic reserves, which are commonly observed in the aging population [22]. Severe and higher-level dyspnea significantly impacts daily living activities, which in turn negatively affects the 6MWT distance and PFSDQ-M scores. These findings emphasize the importance of early screening for respiratory functional impairments in the aging population, especially in those with no history of respiratory disease [23].

The decline in the MEP and MIP values in the elderly group clearly indicated the presence of early respiratory muscle weakness, which can be responsible for increased dyspnea experienced during exertional activities. An increase in respiratory muscle strength and functional capacity can help maintain respiratory fitness in the aging population and also prevent the development of respiratory comorbid health conditions.

This study's findings clearly demonstrate that a simple and non-invasive assessment can help detect clear differences in respiratory function between young and older individuals. These results emphasize the importance of developing preventive strategies that can help prevent respiratory functional deterioration associated with advancing age and also maintain respiratory fitness. These strategies may include aerobic exercise, respiratory muscle training, and techniques for managing dyspnea.

Conclusion

Healthy aging is associated with increased dyspnea severity, reduced functional exercise capacity, and decreased respiratory muscle strength, in the absence of diagnosed cardiopulmonary disease. The correlations between dyspnea, functional limitation, and respiratory muscle performance indicate that dyspnea in older adults may be a sign of early respiratory functional decline rather than normal aging. Early detection of these changes using clinical assessments may support timely preventive and rehabilitative interventions to preserve functional independence in aging populations.

Limitations

This study has certain restrictions. First, the small convenience sample and cross-sectional design restrict the capacity to draw conclusions about causality and generalizability. Furthermore, there was no control of possible confounders (such as smoking, physical activity, and body composition) or thorough cardiopulmonary diagnostic testing. Third, the 6MWT, MIP/MEP, and subjective dyspnea questionnaires might not adequately represent the intricate physiological mechanisms underlying dyspnea in healthy aging.

Ethical Considerations

The rules and regulations set by the research committee of the M. Islam Medical and Dental College, Gujranwala were followed while conducting the research.

Consent for publication

I gave the consent to publish my research paper.

Availability of data and materials

Data is available on the research websites.

Competing interests

There are no competing interests.

Funding

This was a self-funded study.

Authors' contributions:

1,2 and 5 wrote the introduction and methodology.
1, 4, 5 wrote the manuscript.
1, 2, 3, 6 and 7 carried out the data collection and analysis.
1, 7 and 3 conceived the original idea.
6 supervised the project.

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