Short Communication

Physical exercise and chicken egg white supplementation increase muscle mass of stable COPD patients

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Abstract

Patients with chronic obstructive pulmonary disease (COPD) commonly exhibit muscle atrophy and dysfunction due to a reduction in muscle mass; and protein supplements such as chicken egg whites have been reported to improve muscle mass. The aim of this study was to evaluate the impact of physical exercise and egg white supplementation on the muscle mass of COPD patients. An experimental study was conducted among stable COPD patients at Universitas Sumatra Utara Hospital Medan, Indonesia, between August and October 2022. The patients were divided into two groups, control and interventional groups, with each patient subjected to a pre- and post-muscle mass assessment. All the patients performed respiratory endurance and upper extremity muscle strength training three times/week for a total of 12 weeks. In addition, the patients in the intervention group were also given egg white supplementation (10 eggs/day) during the period of intervention in addition to the physical training. The Wilcoxon and Mann-Whitney tests were performed to identify the significance of the difference between pre- and post-intervention and between the control and intervention groups, respectively. A total of 38 COPD patients were included in the study, 19 from each group. Our data suggested no significant difference in muscle mass of the patients in the control group before and after 12 weeks of physical exercise (pre-intervention 27.37±4.54% and post-intervention 27.68±4.5% with p=0.174). However, there was a significant muscle mass increment of patients in the intervention group upon 12 weeks of physical training and egg white supplementation (pre-intervention 27.18±4.15%, post-intervention 29.95±3.76%, p<0.001). A significant difference in muscle mass was observed between patients in the control and the intervention groups (p=0.046) after the intervention. The study highlights that physical exercise in combination with egg white supplementation may serve as potential and effective non-pharmacological treatment for muscle mass restoration in COPD patients as compared to physical exercise alone.

Keywords: COPD, muscle mass, physical exercise, protein supplement, malnutrition

Introduction

Chronic obstructive pulmonary disease (COPD) was the third leading cause of death worldwide in 2020, and it was estimated that the prevalence exceeded more than 300 million people in 2013.

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In Asia Pacific, it was recorded that in 2015, at least 6.2% of the population experienced COPD, of which 19.1% suffered from severe COPD. COPD is one of the four most serious non-communicable diseases, contributing to 60% of deaths in Indonesia. Approximately 70% of the overall healthcare costs are associated with COPD patients along with the increase of COPD management annual cost in proportion to the number of COPD exacerbations. The Indonesian Society of Respirology (PDPI) stated that in 2015, at least 4.5–5.5% of the Indonesian population had COPD and this figure could increase to 7.2% in rural areas [1,2].

While tobacco smoking is a major risk factor for COPD, only approximately 20% of smokers develop the disease. More evidence is rising to suggest that other risk factors such as air pollution, respiratory infections, poor nutritional status, chronic asthma, impaired lung growth, poor socio-economic status, and genetic factors play a crucial role in disease development. About 15–20% of COPD cases are due to occupational exposures to pollutants at the workplace, and about 50% of COPD mortality cases in developing countries have been exposed to biomass smoke during their lifetime [1,2].

Skeletal muscle atrophy, commonly seen in respiratory organs, leads to the loss of muscle mass in patients with COPD. The complex interaction leading to skeletal muscle dysfunction involves various factors, either local or systemic, including inflammatory response, malnutrition, drugs, age, and hypoxia [3,4]. Muscle dysfunction in COPD patients may lead to various clinical outputs such as mortality, a poor quality of life, and exercise intolerance, regardless of lung function problems. Therefore, increasing muscle function, through physical exercises, is considered an important goal in COPD management and pulmonary rehabilitation to reduce symptoms, optimize functional status, and minimize healthcare costs [5,6].

Malnutrition, as mentioned earlier, is closely related to decreased lung function in COPD patients. Thus, providing proper nutrition is part of therapy in COPD patients [2,7]. A study suggested that 21% of COPD patients experienced malnutrition and 57% were at risk of malnutrition [8]. It has also been implied that malnutrition incidence increases along with the development of disease severity, and is considered essential prognostic factors for COPD patients. The occurrence of malnutrition is a consequence of increased energy demand due to the increased activity of respiratory muscles, leading to a hypermetabolism state that reduces muscle mass, alters body proportions and muscle fiber size, as well as promotes muscle dysfunction. Nutritional supplementation is a necessary therapeutic intervention for COPD patients, as it significantly increases one's body weight and muscle strength. According to the European Society for Clinical Nutrition and Metabolism (ESPEN) recommendation, protein requirement in elderly individuals with acute or chronic disease increases up to 1.2–1.5 g/kg BW/day [8-11]. Nutritional supplements, such as protein in particular, have been reported to improve body weight, handgrip strength, and respiratory muscle strength in COPD patients [12]. The aim of this study was to determine the effect of physical exercise and egg white supplementation on muscle mass in stable COPD patients [5].

Methods

Study design and setting

An experimental study design was carried out among stable COPD patients at Universitas Sumatra Utara (USU) Hospital Medan, Indonesia, between August and October 2022. Details of the study are available elsewhere [12]. The diagnosis of COPD was determined based on the patient's medical history, physical examinations, and confirmed by a spirometry examination. The patients were divided into two groups, namely control and interventional groups. Each patient in both groups was subjected to a pre- and post-test.

Sample size

Total sampling method was employed in this study, including patients of stable COPD, who had a history of smoking, were aged 40–80 years old, had not engaged in any physical exercise in the month leading up to the intervention, and were able to use a smartphone application. COPD patients who had an exacerbation history within the last month, severe infections and sepsis, cardiovascular disorders (such as acute coronary syndrome or chronic heart failure), and long-term oxygen therapy were excluded from the study.

Intervention

The patients in the intervention group were subjected to physical exercise and egg white supplementation, whereas those in the control group underwent only physical exercise without egg white supplementation. Several information of patients from both groups (intervention and control) were assessed prior to the intervention, including vital signs, body weight (kg), height (cm), oxygen saturation, spirometry, dyspnea scale based on the modified Medical Research Council (mMRC), COPD assessment test (CAT), uric acid level, and muscle mass using the Omron Carada Scan scale to obtain pre-intervention baseline data. Afterward, all the subjects in both the control and treatment groups underwent respiratory endurance and upper extremity muscle strength training. The exercise was conducted three times a week with a 30-minute duration for a total of 12 weeks.

Egg white supplementation in the interventional group was given as much as 10 eggs/exercise, three times/week during the period of treatment in addition to the exercises. The exercise was accomplished independently by all the patients using a COPD smartphone application guide installed on their smartphones. Supervision and monitoring were carried out through a WhatsApp group, where each patient was required to send their exercise video to the group and depict the consumption of egg whites for the patients in the intervention group. At the end of the 12-week period, the muscle mass of all patients was remeasured with the Omron Carada Scan scale to obtain post-intervention data.

Statistical analysis

The collected data were analyzed using SPSS software (SPSS Inc, Chicago, USA). Numerical variables, demographic characteristics, and clinical findings were presented in percentage (%) and mean ± standard deviation (SD). Wilcoxon test was performed to determine the significance of differences between the pre- and post-test, whereas and Mann-Whitney U test was used to evaluate the significance of differences between the intervention and control groups. A p-value of ≤ 0.05 was considered statistically significant.

Results

Baseline characteristics of the patients

The process of our study recruitment and follow-up are presented in **Figure 1**. Throughout the course of the study, 50 patients were enrolled. However, 12 participants discontinued the study due to follow-up and adherence problems. This made a total of 38 patients with stable COPD included in this study (**Figure 1**).

The patient's demographic and clinical characteristics are presented in **Table 1**. All of the patients were male and most of them were within the age group of 60–69 years (control: 47.37%; intervention: 68.42%). Overall, most of the patients in both groups possessed different types of comorbidities, with hypertension being the most prevalent coexisting condition (control: 31.5%; intervention: 26.3%). The vast majority of the patients were heavy smokers based on the Brinkman index calculation, and the airflow obstruction degree analysis, measured by spirometry test, indicated that more than half of the subjects (57.9%) were in the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2 category.

Patients' muscle mass before and after the intervention

The data on patients' muscle mass before and after the intervention are illustrated in **Figure 2.** The result of the Wilcoxon test revealed no significant difference in the muscle mass of COPD patients in the control group before and after 12 weeks of physical exercise (p=0.174). However, a significant increment was observed in the muscle mass of the patients in the intervention group before and after 12 weeks of both physical exercise and egg white supplementation (p=0.001).

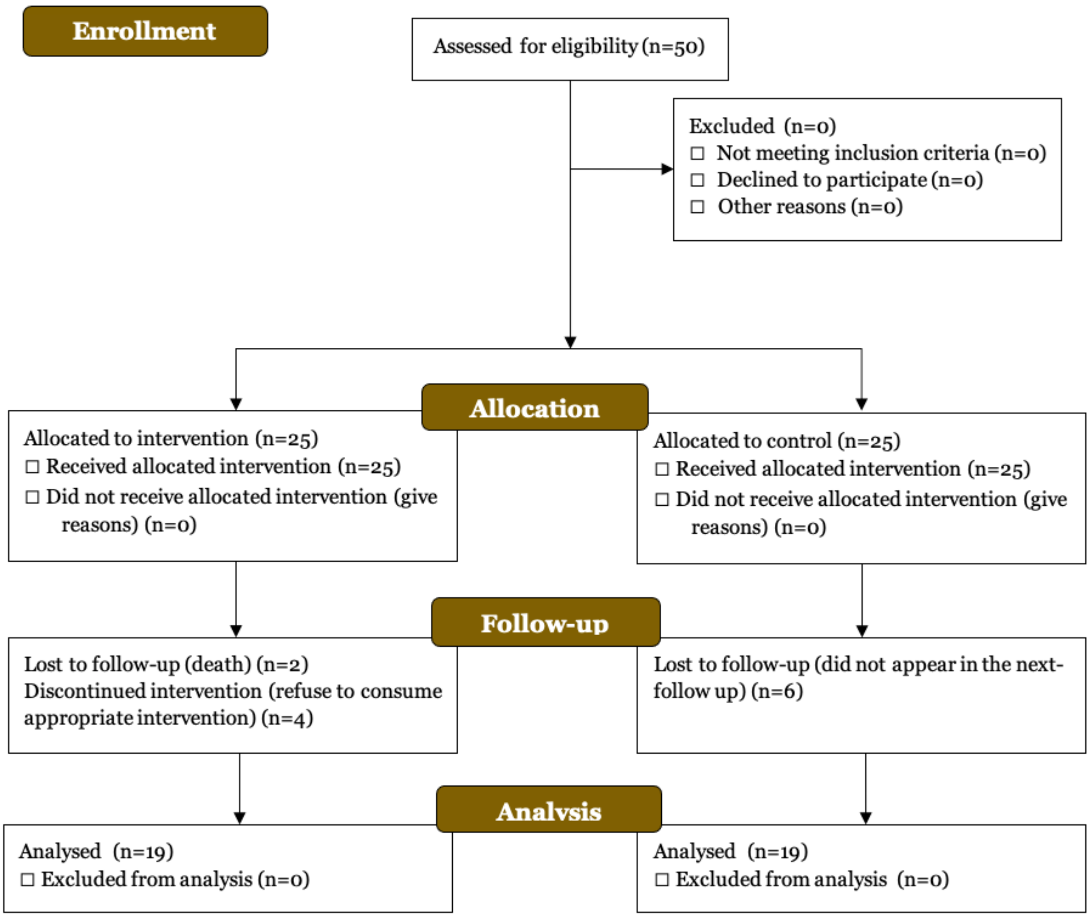

Figure 1. Consort flow diagram of the study.

Table 1. Characteristics of the COPD patients included in this study (n=38)

Characteristics	Control group		Interventional group	
	n	%	n	%
Gender				
Male	19	100.0	19	100
Female	0	0.0	0	0.0
Age (years)				
40–59	7	36.8	2	10.5
60–69	9	47.4	13	68.4
70–80	3	15.8	4	21.1
Comorbidities				
None	8	42.1	6	31.6
Hypertension	6	31.5	5	26.3
Lung tuberculosis	3	15.8	4	21.1
Diabetes	1	5.3	2	10.5
Hepatitis C	1	5.3	0	0.0
Hyperuricemia	0	0.0	1	5.3
CHF	0	0.0	1	5.3
Smoking status (Brinkman index)				
Mild	0	0.0	0	0.0
Moderate	4	21.1	1	5.3
Heavy	15	78.9	18	94.7
Severity of COPD				
GOLD 1 (mild)	0	0.0	0	0.0
GOLD 2 (moderate)	11	57.9	5	26.3
GOLD 3 (severe)	7	36.8	6	31.6
GOLD 4 (very severe)	1	5.3	8	42.8

GOLD: Global Initiative for Chronic Obstructive Lung Disease

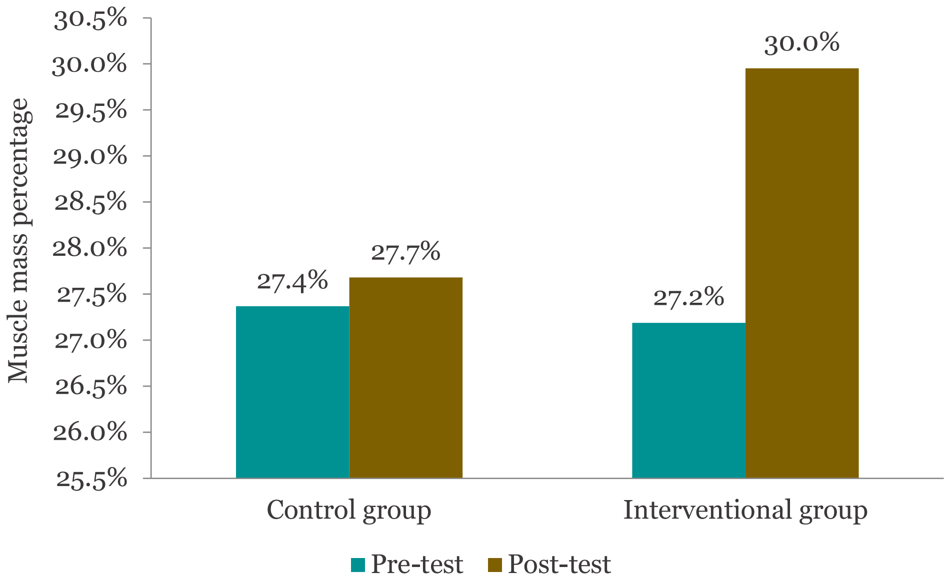

Figure 2. Muscle mass measurement in COPD patients between pre- and post-intervention in control and intervention groups.

Furthermore, the result of the Mann-Whitney analysis suggested a statistically significant difference (p=0.046) in the mean muscle mass between the control (15.89%) and intervention (23.11%) groups post-intervention (**Table 2**) suggesting a significant impact of egg white supplementation on muscle mass restoration in COPD patients.

Table 2. Comparison of muscle mass between control and intervention groups post-intervention

Group	Mean	Sum of rank	*p*-value
Control group	15.89	302.0	0.046
Intervention group	23.11	439.0	

Analyzed using Mann-Whitney test

Discussion

The patients in this study were all males and almost all of them were heavy smokers. A higher prevalence of cigarette smoking and frequent exposure to environmental pollutants has been associated with a higher prevalence of developing COPD among men [13,14]. High tobacco consumption induces the release of tumor necrosis factor alpha (TNF-α) by alveolar macrophage, resulting in an increased matrix metalloproteinase (MMP) production, which in turn, destroys the smoker's respiratory system. However, the fact that not every smoker develops clinical COPD, genetic polymorphism has been considered another factor related to the pathogenesis of COPD [2].

COPD patients who often experience respiratory muscle weakness and respiratory muscle dysfunction have been associated with dyspnea and worse ventilation response while exercising and exacerbation. Hence, physical exercises play a crucial role in restoration of the respiratory muscle function [14]. In addition, COPD patients also often suffer from cachexia, a severe loss of body weight with an unproportionate muscle diminution. COPD causes gradual loss of muscle protein and results in skeletal muscle atrophy. Depletion of respiratory muscle leads to lung dysfunction, alters patients' exercise tolerance, reduces quality of life, induces decondition, and increases mortality [15,16]. Thus, nutritional supplementation, such as protein in particular, is another critical factor in the treatment of COPD patients.

Our study indicated that COPD patients undergoing the physical exercise along with additional egg white supplementation exhibited significantly increased muscle mass, suggesting a significant effect of physical exercise in combination with egg white supplement on muscle function restoration. Our finding aligns with previous studies that reported physical exercise and protein supplementation could significantly increase muscle mass and muscle strength in COPD patients, and subsequently improve patients' ability to perform daily activities and thereby increase the quality of life for COPD patients [13,14]. However, other studies exhibited that physical exercise alone such as aerobics could also improve the muscle mass of stable COPD patients [17]. Physical exercises can improve respiratory patterns, enhance respiratory muscle strength and endurance, increase ventilation and lung function, ameliorate exercise capacity and cardiovascular function, as well as alleviate dyspnea and mood disturbance in the daily life of COPD patients [18,19].

This study is consistent with a previous study that demonstrated COPD patients attending pulmonary rehabilitation with a high protein diet combined with physical exercise had a clinically better effect on walking distance and had better six-minute walk test (6MWD) after 12 weeks compared to the control group [20]. In addition, low-intensity physical exercises reduced the risk of hospitalization in COPD patients [21]. Another study found that in obese COPD patients, dietary energy restriction coupled with resistance exercise training resulted in clinically significant improvements in body mass index, exercise tolerance and health status while preserving skeletal muscle mass [22]. However, another study found that combined aerobic and resistance training with functional exercises failed to improve personal activities of daily living (PADL) and activities of daily living (ADL) limitations in COPD patients [23].

This study possessed several limitations that should be addressed. The study did not assess the patient's renal function and potassium measurements to evaluate possible adverse effects of egg white supplementation, considering that high protein consumption causes calcium excretion from the body and increases renal activity. Furthermore, this study did not employ Bioelectrical Impedance Analysis (BIA), a widely known gold standard tool, to determine the muscle mass absorption values due to the limited available facilities.

Conclusion

Our results suggested that the provision of physical exercises (respiratory endurance and upper extremity muscle strength training) and egg white supplementation for 12 weeks significantly increased muscle mass in patients with COPD, highlighting that pulmonary rehabilitation and egg white supplementation serves as a safe and effective non-pharmacological treatment for COPD patients.

Ethics approval

This study was approved by the Ethical committee of Universitas Sumatera Utara, Medan, Indonesia (approval no: 1198/KEPK/USU/2022).

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

How to cite

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