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Functional capacity and quality of life improvement in stable chronic obstructive pulmonary disease (COPD) patients following physical exercise and chicken egg white supplementation

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Abstract

The pillars of comprehensive pulmonary rehabilitation program for chronic obstructive pulmonary disease (COPD) patients include physical exercise and good nutrition. The aim of this study was to evaluate the efficacy of pulmonary rehabilitation, which included physical exercise and chicken egg white supplementation, on the quality of life (QoL) and functional capacity among patients with stable COPD. The COPD patients were enrolled prospectively in this quasi-experimental study and completed a 12-week smartphone-guided home-based physical exercise program that comprised strength and resistance training three times per week for 30 minutes each session. Participants were divided into two groups: the control group who underwent physical exercise only, and the intervention group who had physical exercise and chicken egg white supplementation as a protein source. Patient characteristics including sex, age, nutritional status, comorbidities, smoking status, and obstruction severity, were evaluated. The COPD assessment test (CAT) score and six-minute walk test (6MWT) were used as the parameters to evaluate QoL and functional capacity, respectively. Of the total 50 patients included in the study, 12 were excluded due to follow-up and adherence problems. Our data indicated there were significant CAT score reduction and 6MWT improvement in both control and intervention groups after 12 weeks compared to baseline data. However, reduction of mean CAT score was higher in intervention compared to control group (-13.47±6.49 vs -5.42±5.07, p<0.001). In addition, the improvement of 6MWT was also higher in intervention group compared to control group (145.47±69.2 vs 32.42±17.3 meters, p<0.001). In conclusion, chicken egg white supplement to male patients with stable COPD who exercise with resistance and strength training could improve the QoL and functional capacity.

Keywords: COPD, physical exercise, chicken egg white, 6MWT, CAT score

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Introduction

Patients with chronic obstructive pulmonary disease (COPD), the majority of whom are elderly, experience a negative cycle of physical inactivity, decreasing muscle mass, and increasing

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shortness of breath. The key element required to stop the cycle is a comprehensive pulmonary rehabilitation program. Exercise has been shown to be beneficial in all stages of COPD as part of pulmonary rehabilitation programs, improving exercise tolerance, muscular strength, quality of life (QoL), and lowering levels of exhaustion and shortness of breath [1-3].

Despite the benefits, the number of COPD patients who carry out pulmonary rehabilitation programs routinely is very low due to various problems, including the inability to carry out physical activity due to muscle weakness, shortness of breath, transportation problems, schedule discrepancies, and difficulty accessing the pulmonary rehabilitation center [4-7]. Currently, exercise programs for COPD patients conducted outside of medical institutions, such as gyms, private homes, and online, may represent a new approach that will draw in more patients and ensure that these programs are implemented for a longer period of time and are more satisfactory. Several studies have been done to evaluate the efficacy of pulmonary rehabilitation programs run outside of medical facilities [4-7]. This program was specifically created for each patient based on their own requirements. Furthermore, it is anticipated that the use of smartphone applications will facilitate and make it simpler for COPD patients to engage in physical exercise whenever they decide, in accordance with their level of comfort and time availability, in order to increase their participation and further maximize the advantages of physical exercise on functional capacity [3-9].

Providing protein supplements to elderly, particularly COPD patients, has been linked to weight gain, improved muscular function, lower risk of hospitalization and mortality, and higher nutritional status [10-12]. Protein supplementation significantly increased muscle mass and exercise capacity [13]. The aim of this study was to simultaneously assess the effect of independent smartphone-guided physical exercise along with the effect of adding chicken egg white in stable COPD patients.

Methods

Study setting

A quasi-experimental study was conducted among COPD patients throughout January 2021 to December 2022 at Prof. dr. Chairuddin Panusunan Lubis Universitas Sumatera Utara Hospital and Siti Hajar Hospital, Medan, Indonesia. After selected, the study participants, who were divided into control and intervention groups, completed the COPD assessment test (CAT) questionnaire and the six-minute walk test (6MWT) as baseline data. The control group performed independent physical exercise three times per week for a length of 30 minutes over a 12-week period utilizing the "PARU SEHAT" application guidance on an Android smartphone. In addition to participating in physical exercise, the intervention group consumed egg white supplementation of 10 eggs/exercise. After 12 weeks of study, CAT score and 6MWT were reassessed to determine the QoL and functional capacity, respectively.

Patient selection and criteria

Using a non-probability sampling technique with consecutive sampling, COPD patients who were diagnosed according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD)/Indonesian Society of Respirology (ISR) were recruited from the outpatient respiratory clinic at Prof. dr. Chairuddin Panusunan Lubis Universitas Sumatera Utara Hospital and Siti Hajar Hospital, Medan, Indonesia. All subjects who arrived sequentially and met the eligibility requirements were included in the study.

The inclusion criteria in this study were: (a) age range of 40 to 80 years old; (b) receiving appropriate therapy provided by outpatient clinic based on COPD groups; (c) absence of malignancy, severe cardiovascular disease such as acute coronary syndrome or acute chronic heart failure, neuromusculoskeletal disorders such as stroke, severe osteoarthritis, or other illnesses that affect the movement, renal diseases, impaired cognitive; (d) not having a history of egg allergy; and (e) able to utilize Android smartphone application. Patients who did not implement the intervention as advised, experienced interference preventing subjects from performing the intervention, passed away during the study, or withdrew from participation were excluded from the study. All patients provided their informed consent before participating in this study.

Procedure and variables

The patients were divided into two groups: the control group performed physical exercise only, and the intervention group did physical exercise and provided with chicken egg white supplementation. At the time of admission, the patient characteristics including sex, age, nutritional status based on body mass index (BMI), and comorbidities were collected. Smoking status was calculated by multiplying years of smoking by the daily cigarette consumption (Brinkmann index) and obstruction severity was classified according to Global Initiative for Chronic Obstructive Lung Disease (GOLD). The endpoints (functional capacity and quality of life (QoL)) were measured at the time of admission and at the end of the study.

Interventions

Physical exercise included strength and resistance training guided by Android smartphone application "PARU SEHAT". Physical exercise adopted in this study were adjusted to patients' individual capabilities based on recommendations for resistance (**Table 1**) and strength trainings (**Table 2**).

Table 1. Endurance training recommendation adopted in the study

Component	Continuous endurance training	Interval resistance training
Frequency	3–4 days/week	3–4 days/week
Mode	Continuous	Interval mode: 30 seconds of exercise, 30 seconds of rest, or 20 seconds of exercise, 40 seconds of rest
Intensity	Initially 60–70% of peak work rate Increase workload by 5–10% as tolerated Progressively tried up to 80–90% of baseline peak work rate	Initially 80–100% of peak work rate for the first three to four sessions Increase workload by 5–10% as tolerated Gradually try to reach 150% of baseline peak work rate
Duration	Initially 10–15 minutes for the first three to four sessions Progressively increase the duration of the exercise to 30–40 minutes	Initially 15-20 minutes for the first three to four sessions Progressively increase exercise duration to 45–60 minutes (including rest time)
Borg scale	4–6	4–6
Breathing techniques	Recommend pursed lip breathing or use of a positive expiratory pressure device to prevent dynamic hyperinflation and to reduce respiratory rate	Recommend pursed lip breathing or use of a PEP device to prevent dynamic hyperinflation and to reduce respiratory rate

Adapted from Ambrosino and Strambi [14].

Table 2. Strength training recommendation adopted in the study

Component	Description
Frequency	2–3 days/week
Objective	Targets fatigue in muscle groups, especially the upper and lower extremities through a certain number of repetitions of movements
Mode	Two to four sets of 6 to 12 repetitions while lifting load of 0.5 kg in both hands
Intensity	50–85% of 1RM (one repetition maximum) as a reference point Increase workload by 2–10% if one or two repetitions above the desired number is still possible on two consecutive training sessions
Tempo	Medium (1–2 seconds concentric and 1–2 seconds eccentric)

Adapted from Nici *et al.* [15].

Using the conversion of daily protein requirement for people over the age of 40, 30 grams of chicken egg white supplementation, up to 10 eggs per day, was provided. Physical exercise was practiced three times per week for a minimum of 30 minutes per day for 12 weeks. The consumption of chicken egg whites was done on the same day as the exercise day. By requesting the patients to provide videos of themselves exercising, consuming chicken egg whites, and filling out a timetable for their physical exercise, an evaluation of the intervention's implementation was carried out on a daily basis.

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Endpoints

The endpoints evaluated in this study were functional capacity and QoL. Six-minute walk test (6MWT), conducted in accordance with American Thoracic Society (ATS) recommendations, was used to evaluate functional capacity while COPD assessment test (CAT) score was used to evaluate QoL. At the time of admission and at the end of the study, the CAT score and 6MWT were evaluated. The CAT scales from 0 to 40. A higher score denotes a more serious disease impact.

Statistical analyses

All variables were calculated for the arithmetic mean, percentage, and standard deviation (SD). Fisher's Exact test was used to examine the homogeneity between group. The Shapiro-Wilk test was used to determine normality and revealed the data were distributed normally. The independent Student t-test was used to assess the association between intervention and outcomes. A two-tailed $p<0.05$ was considered to be statistically significant.

Results

Subject characteristics

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 were involved with a mean age of 66.97±6.25 years (range 54–80 years) (**Table 3**). All of the patients were male. The majority of the control and intervention groups were >60 years old (84.2% and 89.5%, respectively); 68.4% and 94.7% had a smoking history with a severe Brinkman index, respectively. Overall, there was no difference in characteristics between the control and intervention groups (**Table 3**).

Table 3. Characteristics of stable chronic obstructive pulmonary disease (COPD) patients included in this study

Characteristics	Control group (*n*=19) *n* (%)	Intervention group (*n*=19) *n* (%)	Total *n* (%)	*p*-value
Sex				
Male	19 (100.0)	19 (100.0)	38 (100.0)	1.00
Female	0 (0.0)	0 (0.0)	0 (0.0)	
Age (years)				
51–60	3 (15.8)	2 (10.5)	5 (13.1)	0.62
61–70	8 (42.1)	13 (68.4)	21 (55.2)	
71–80	8 (42.1)	4 (21.1)	12 (31.5)	
Nutritional status (BMI, kg/m2)				
Underweight (<18.5)	2 (5.3)	2 (5.3)	4 (10.5)	0.45
Normal (18.5–24.9)	7 (18.4)	8 (21.1)	15 (39.5)	
Overweight (25.0–29.9)	2 (5.3)	5 (13.2)	7 (18.4)	
Obese (≥30)	8 (21.1)	4 (10.5)	12 (31.6)	
Comorbidity				
None	3 (13.6)	5 (22.7)	8 (18.1)	0.43
Hypertension	13 (59.1)	7 (31.8)	20 (45.5)	
Pulmonary tuberculosis	4 (18.2)	6 (27.3)	10 (22.7)	
Type 2 diabetes mellitus	1 (4.5)	2 (9.1)	3 (6.8)	
Hepatitis C	1 (4.5)	0 (0)	1 (2.3)	
Hyperuricemia	0 (0.0)	1 (4.5)	1 (2.3)	
Congestive heart failure	0 (0.0)	1 (4.5)	1 (2.3)	
Smoking status (Brinkman Index)				
Mild (1–199)	2 (10.5)	0 (0.0)	2 (5.3)	0.10
Moderate (200–599)	4 (21.1)	1 (5.3)	5 (13.2)	
Severe (≥600)	13 (68.4)	18 (94.7)	31 (81.6)	
Obstruction severity				
GOLD 1 (mild)	0 (0.0)	0 (0.0)	0 (0.0)	0.07
GOLD 2 (moderate)	12 (63.2)	5 (26.3)	17 (44.7)	
GOLD 3 (severe)	4 (21.1)	6 (31.6)	10 (26.3)	
GOLD 4 (very severe)	3 (15.8)	8 (42.1)	11 (28.9)	

GOLD: Global Initiative for Chronic Obstructive Lung Disease

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COPD assessment test (CAT) score

At the time of admission, the mean CAT scores of control and intervention groups were 16.21±6.27 and 20.32±8.79, respectively (**Table 4**). After 12 weeks of intervention, the mean CAT scores of control and intervention groups decreased to 10.79±3.71 (p=0.003) and 6.84±3.61 (p=0.020), respectively which shown significant improvement compared to baseline data in both groups (**Table 4** and **Figure 1A**). The mean decrease of CAT scores for control group was 5.42±5.07 and 13.47±6.49 for intervention group (**Table 4** and **Figure 2A**). Analysis of CAT score reduction indicating there was a significant change between control and intervention groups, p<0.001 (**Table 4**).

Table 4. Comparison of COPD assessment test (CAT) score and six-minute walk test (6MWT) between study groups

Outcome	Control group		Intervention group		*p*-value [b]
	Pre	Post	Pre	Post	
CAT score					
Mean (±SD)	16.21±6.27	10.79±3.71	20.32±8.79	6.84±3.61	<0.001
Mean change (±SD)	-5.42±5.07		-13.47±6.49		
p-value [a]	0.003		0.020		
6MWT (meters)					
Mean (±SD)	276±85.14	308.4±82.66	223.8±82.67	369.3±99.01	<0.001
Mean change (±SD)	32.42±17.26		145.47±69.17		
p-value [a]	<0.001		<0.001		

[a] Comparison between mean pre and post within control group or intervention group
[b] Comparison between mean change of two groups (control and intervention groups)

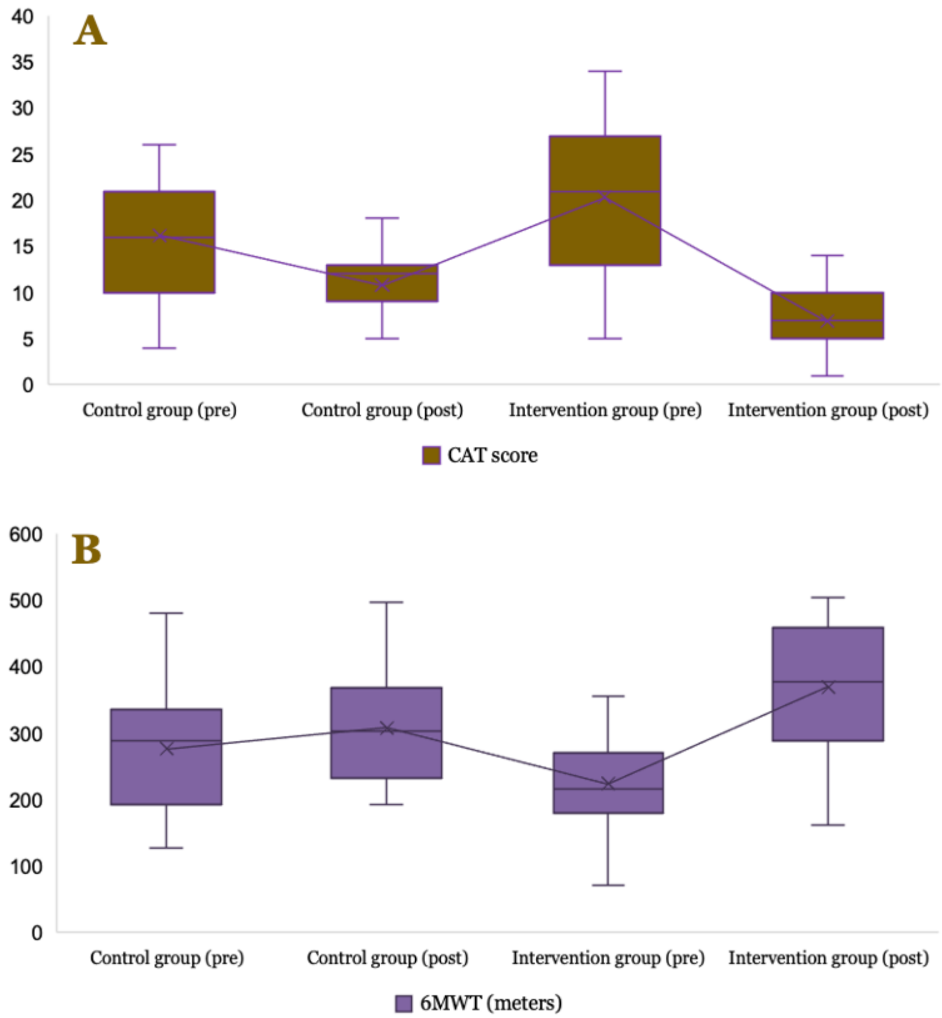

Figure 1. Improvement of COPD assessment test (CAT) score (A) and six-minute walk test (6MWT) (B) among stable COPD patients following physical exercise only or combination with chicken egg white supplementation.

Six-minute walk test (6MWT)

The baseline mean of 6MWT for control and intervention groups was 276±85.1 and 223.8±82.7 meters, respectively (**Table 4**). Compared to the baseline data, the mean 6MWT for control and intervention groups increased significantly to 308.4±82.7 meters (p<0.001) and 369.3±99 meters (p<0.001), respectively, after 12 weeks (**Table 4** and **Figure 1B**). Participants in intervention group experienced a higher average rise of 6MWT (145.47±69.2 meters) compared to control group (32.42±17.3) (**Table 4** and **Figure 2B**). Our data indicated that the 6MWT improvement was significantly higher in intervention group compared to control group (p<0.001) (**Table 4**).

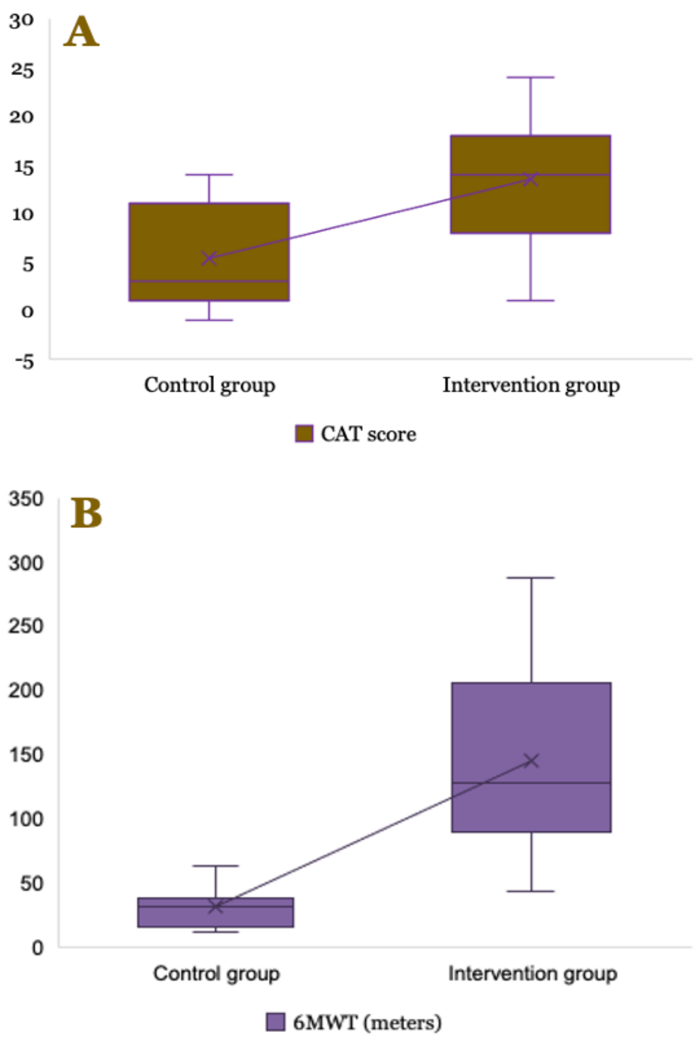

Figure 2. Changes of COPD assessment test (CAT) score (A) and six-minute walk test (6MWT) (B) between control group (physical exercise only) and intervention group (combination of physical exercise and chicken egg white supplementation).

Discussion

Our data indicate that there was an improvement in QoL and functional capacity in COPD patients who engaged in resistance and strength training and consumed chicken egg whites. Patients who completed physical exercise alone shown substantial benefits, and the benefits increased when physical exercise was combined with diet changes that included chicken egg whites. These suggest that chicken egg whites as protein supplements along with physical exercise promote protein anabolism as contrasted to catabolism and preserve muscle physiology and morphology. The CAT scores of control and intervention groups differed significantly. Compared to the control group, who engaged only in physical exercise, CAT score of the intervention group, who received chicken egg white supplementation, was lower. A CAT score reduction of 2 points is considered a minimum clinically important difference (MCID) in individuals with COPD [16]. Hence, supplementing with chicken egg whites can enhance the QoL for COPD patients who exercise.

A comprehensive pulmonary rehabilitation program must include physical exercise as the main element. Physical exercise has shown to be useful at all stages of COPD. This improves exercise tolerance, muscular strength, QoL, and lowering levels of fatigue and shortness of breath [1-3]. There was a substantial improvement in exercise capacity, functional capacity, and QoL in 40 COPD patients who were randomized to the intervention of resistance and strength training three times per week for 12 weeks [17]. This is consistent with the findings of this research.

Apart from physical exercise, diet plays a significant role in pulmonary rehabilitation. With aging, muscle depletion is made worse by COPD, which is frequently accompanied by a rise in the rate of protein breakdown and a reduction in the rate of protein synthesis [18]. In accordance with the results of this present study, other studies have demonstrated that supplying nutrition, particularly protein, can significantly enhance functional capacity and QoL while also lowering morbidity and mortality in COPD patients [10,19]. Khan *et al.* found a significant improvement in the 6MWT and QoL after consuming a high-protein diet [20]. In COPD patients undergoing pulmonary rehabilitation, high-protein supplementation can reduce clinical symptoms and increase exercise tolerance in a way that is beneficial to and acceptable to the patients [21].

With the help of video guidance, our study participants independently performed physical exercise at home. This shows that, despite the fact that traditionally supervised pulmonary rehabilitation is still the gold standard and first option of treatment, home-based pulmonary rehabilitation is a promising substitution. The degree of shortness of breath in COPD patients can be improved, according to data that is comparable to that found in this study and supports the use of home-based pulmonary rehabilitation programs [7].

Non-compliance and improper physical exercise technique are the challenges in implementing this home-based rehabilitation. This was avoided in this current study by requesting participants to provide recordings of their physical exercise sessions and to report their attendance on a regular basis so that the discipline and precision of their movements could be evaluated. Lethargy, apprehension that shortness of breath would worsen, and physical weakness were common reasons why patients refrained from participation. Healthcare professionals must thus inform patients that physical inactivity genuinely does have negative impacts: it increases morbidity, increases the likelihood of exacerbations, and diminishes QoL [22]. The physical exercise used in this study were relatively simple and performed in a sitting position, allowing COPD patients to tolerate even the most severe degrees of obstruction (GOLD 4).

Eggs are an inexpensive, easy-to-find, and easily digestible source of high-quality protein. The most predominant protein in plasma is albumin, which is found in egg white. Albumin helps to regulate blood osmotic pressure, transports numerous compounds through the circulation, and lowers blood acidity. All of the necessary amino acids that the body requires are present in egg white, which also provides a number of health benefits like boosting the immune system and cell development [23-25]. Egg white comprises 11–12% protein, with ovalbumin, which is regarded as the egg white's primary protein, making up the majority (54%), followed by conalbumin (12%), ovomucoid (11%), lysozyme (3.5%), and ovomucin (3.5%) [26]. Consequently, egg whites are a good source of protein for those who require high amounts of protein, such as elderly COPD patients. The protein found in egg whites is also affordable, accessible, and free of cholesterol. Consuming protein sources from egg whites can improve QoL and functional capacity in COPD patients. Given that COPD is a chronic, progressive, and irreversible disease dietary supplementation with chicken egg white are essential. Our data indicated that combination of home-based exercise under supervision and chicken egg white supplementation was effective to improve the QoL of COPD patients,

There are some limitations of this study. Besides the limited number of study participants, it cannot be conclusively said that the treatments were advantageous for female COPD patients since all study participants were men due to the small number of women with COPD at the study location. Therefore, further study that takes into account more COPD patients is required.

Conclusion

Implementation of independent physical exercise guided by Android smartphone application could improve the QoL and functional capacity of stable COPD patients. In addition, combination of chicken egg white supplementation with physical exercise exhibits even greater advantages. Therefore, besides pharmacological management, non-pharmacological therapy for stable COPD patients in outpatient clinics in the form of implementing independent smartphone-guided physical exercise accompanied by supplementation of chicken egg white diet is strongly recommended, especially for male patients.

Ethics approval

The Universitas Sumatera Utara Health Research Ethics Committee approved this study with the approval number 503/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.

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