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ARAŞTIRMA YAZISI / RESEARCH ARTICLE

KOAH'TA QUADRİCEPS FEMORİS VE GASTROCNEMİUS KAS EĞİTİMİNİN GÜNLÜK YAŞAM AKTİVİTELERİNE ETKİSİNİN KARŞILAŞTIRILMASI

COMPARISON OF THE EFFECTS OF QUADRICEPS AND GASTROCNEMIUS MUSCLE TRAINING ON ACTIVITIES OF DAILY LIVING IN COPD

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ÖZET

AMAÇ: Kronik Obstrüktif Akciğer Hastalığı (KOAH), egzersiz toleransında bozulma ve yaşam kalitesinde azalma gibi semptomlara sahiptir. Bu çalışmada stabil KOAH hastalarında quadriseps femoris (QF) ve gastrocnemius (GC) kasları nöromüsküler elektriksel stimülasyon (NMES) ile güçlendirildiğinde KOAH hastalarında egzersiz performansı ve yaşam kalitesi üzerine etkileri karşılaştırıldı.

GEREÇ VE YÖNTEM: KOAH'lı 45 hasta kontrol, gastrocnemius kas (GC Grubu) ve quadriseps femoris kas (QF Grubu) olmak üzere rastgele üç gruba ayrıldı. Kontrol grubuna sadece pulmoner rehabilitasyon, GC grubuna pulmoner rehabilitasyona ek olarak GC kasına NMES ve QF grubuna pulmoner rehabilitasyona ek olarak QF kasına NMES uygulandı. Hastalar tedavi öncesi ve sonrasında Görsel Analog Skala (VAS), Altı Dakika Yürüme Testi, St. George's Respiratory Questionnaire anketi (SGRQ), Kısa Form-36 (SF-36) ve Beck Depresyon Envanteri ile değerlendirilmiştir. İstatistiksel analiz IBM SPSS 23.0 programında yapıldı ve $p<0.05$ anlamlı kabul edildi.

BULGULAR: VAS, fiziksel fonksiyon, Beck Depresyon, altı dakika yürüme ve yorgunluk test verilerinde tedavi öncesi ve sonrası arasında kontrol grubunda fark bulunmazken ($p>0,05$), GC ve QF gruplarında ise istatistiksel olarak anlamlı fark tespit edildi ($p<0,05$). Tüm testlerin tedavi öncesi ve sonrası değerlerinde gruplar arasında anlamlı fark yoktu ($p>0,05$).

SONUÇ: KOAH'lı hastalarda QF veya GC kaslarının güçlendirilmesinin egzersiz performansını ve yaşam kalitesine katkı sağladığı görünmektedir. Ancak KOAH'ta QF ve GC kas eğitiminin yaşam kalitesine etkisi bakımında birbirine üstünlüğü yoktu.

ANAHTAR KELİMELER: Pulmoner Hastalık, Transkütanöz Elektriksel Sinir Stimulasyonu, Kuadriseps Kası, Gastroknemius Kası, Egzersiz.

ABSTRACT

OBJECTIVE: Chronic Obstructive Pulmonary Disease (COPD) has symptoms such as impaired exercise tolerance and decreased quality of life. In this study, the effects on exercise performance and quality of life in COPD patients were compared when the quadriceps femoris (QF) and gastrocnemius (GC) muscles were strengthened by neuromuscular electrical stimulation (NMES) in stable COPD patients.

MATERIAL AND METHODS: Forty-five patients with COPD were randomly divided into three groups as control, gastrocnemius muscle (GC Group) and quadriceps femoris muscle (QF Group). The control group received pulmonary rehabilitation only, the GC group received NMES to the GC muscle in addition to pulmonary rehabilitation, and the QF group received NMES to the QF muscle in addition to pulmonary rehabilitation. Patients were evaluated with Visual Analog Scale (VAS), Six Minute Walk Test, St. George's Respiratory Questionnaire (SGRQ), Short Form-36 (SF-36) and Beck Depression Inventory before and after treatment. Statistical analysis was performed in IBM SPSS 23.0 program and $p<0.05$ was considered significant.

RESULTS: While there was no difference in VAS, physical function, Beck Depression, six-minute walk and fatigue test data before and after treatment in the control group ($p>0.05$), a statistically significant difference was found in the GC and QF groups ($p<0.05$). There was no significant difference between the groups in the pre and posttreatment values of all tests ($p>0.05$).

CONCLUSIONS: Strengthening the QF or GC muscles seems to improve exercise performance and quality of life in patients with COPD. However, QF and GC muscle training in COPD were not superior to each other in terms of their effect on quality of life.

KEYWORDS: Pulmonary Disease, Transcutaneous Electric Nerve Stimulation, Quadriceps Muscle, Gastrocnemius Muscle, Exercise.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a disease characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar damage, usually caused by significant exposure to harmful particles or gases (1). Due to chronic inflammatory response and recurrent infections in the airways; fibrosis, gas exchange abnormalities, air trapping and an increase in the amount of mucus are observed in the small airways (2). Systemic inflammation, hypoxemia and hypercapnia, myopathy due to steroids used, and malnutrition cause peripheral muscle weakness in patients with COPD (3,4). The weakness in peripheral muscles seen in COPD is explained by type 2 fiber, metabolic enzyme, decrease in mitochondrial activations and impaired capillaryization (5). In COPD, it has been reported that loss of strength in lower extremity muscle groups as well as pulmonary dysfunction are effective in decreasing exercise and walking capacity (6). Walking activity, which affects functional activity, is closely related to lower extremity muscle strength (7). Although there are multiple muscles involved in walking activity, the most important ones are the quadriceps femoris and gastrocnemius muscles (7, 8). The quadriceps femoris muscle (QF) is one of the postural muscles and plays an important role in various phases of standing and walking. The gastrocnemius muscle (GC) makes significant contributions to walking activity during heel lift activity at the end of the stepping phase (9, 10).

Neuromuscular electrical stimulation (NMES) is the use of low-level electrical currents to create muscle contraction. It creates contraction by stimulating the nerve fibers in a healthy muscle and directly muscle fibers in a denervated muscle by electrical currents. NMES is a method that has been used successfully to increase the muscle performance as a localized exercise method for weak muscles (11). It is known that quadriceps muscle strengthening with NMES has positive effects on exercise capacity and dyspnea during daily activities in severely decompensated COPD patients (12). In order to increase functional activity in COPD patients, it is important to strengthen the lower extremity muscles as well as pulmonary rehabilitation. However, strengthening all lower extremity muscles individually can be both time-consuming and tiring for a COPD patient. In this study, the possible effects of training the QF and GC muscles, which play an important role in walking activity, on the functional activity levels of stable COPD patients were investigated.

MATERIALS AND METHODS

Study Design

This study was designed as a single blind randomized controlled trial. Patients consecutively admitted to the chest diseases department outpatient clinic of Hitit University Erol Olçok Training and Research Hospital in Çorum and followed according to the "Global Initiative for Chronic Obstructive Lung Disease" (GOLD) classification were randomly (gender and age matched randomization method) divided into three groups of 15 patients each. Only the pulmonary rehabilitation program (Control Group) was applied to the patients in the first group (n=15). In the second group (GC Group), in addition to the pulmonary rehabilitation, 20 minutes of NMES was applied to the GC muscle. In the third group (QF Group), in addition to the pulmonary rehabilitation, 20 minutes of NMES was applied to the QF muscle. This treatment protocol was applied to all patients by physiotherapists in 20 sessions for 4 weeks, with each treatment session for 45 minutes, 5 times a week in total. All assessments before and after treatment were evaluated by a researcher who was blinded to the groups.

Participants

A total of 45 stable COPD patients were included in the study. Inclusion criteria for the study; being between the ages of 18-75, diagnosed as group B stable COPD according to GOLD criteria by one pulmonologist, PaO_2 >55 mm Hg, $PaCO_2$ <45 mmHg in room air (13). Exclusion criteria from the study were; exacerbation, cor pulmonale or respiratory muscle fatigue (abdominal paradox breathing), cardiac instability (with acute MI, congestive heart failure or uncontrollable arrhythmia), musculoskeletal disorder (conditions affecting the exercise ability), and presence of difficulty in communicating.

The study began after obtaining approval from the local ethics committee. The patients were informed about the content, purpose and app-

lication of the study and their consent was obtained. Age, gender, educational status, occupation, marital status, date of the COPD diagnosis, time until the start of treatment and additional diseases of every patient were recorded. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Outcome Measures

Visual Analog Scale: The Visual Analog Scale (VAS) was first used as a pain rating scale by Hayes and Patterson (14) in 1921. It is often used in epidemiological and clinical research to measure pain intensity or frequency. It categorizes pain as mild, moderate and severe (15).

6 Minute Walk Test (6 MWT): The patients were administered to a 6 MWT in accordance with the walking protocol of McGavin et al. (16). In a marked area in the closed hospital corridor, patients were asked to walk the longest distance they could walk for 6 minutes, and heart rate, blood pressure, respiratory rate, finger oxygen saturation, and walking distance at the end of walking were recorded at the beginning and at the end of walking.

St. George's Respiratory Questionnaire (SGRQ): The SGRQ questionnaire was used to evaluate the health-related quality of life of the patients. This questionnaire was developed specifically to determine the severity of the disease in COPD and asthma. Effects of the disease on quality of life are examined in 3 parts: symptoms, activity and daily life. Symptoms; cough, sputum, wheezing and shortness of breath. Physical functions, household chores, and hobbies are questioned to determine activity status. These activities are activities that are limited by shortness of breath. The total score of the questionnaire varies between 0-100. A score of zero indicates normal and a score of 100 indicates maximum disability (17).

Beck Depression Inventory (BDI): BDI (Beck et al.) was developed in 1961 to measure the behavioral manifestations of depression in adolescents and adults. Depression levels according to BDI scores are: 0-13 points, no depression; 14-19 points low; 20-28 points moderate and 29-63 points are classified as high depression. The highest score that can be obtained from the scale is 63. A high total score indicates a high level or severity of depression (18).

Short Form-36 (Short Form 36 – SF 36): SF-36 was used to evaluate the quality of life of the patients. SF-36 is a scale that was developed by Ware in 1987 to be used in examining the health status and quality of life of individuals. The scale, which includes thirty-six statements, is in the form of a multi-title scale that evaluates two main headings (physical and mental dimensions) and eight concepts (physical function, physical role difficulty, emotional role difficulty, energy/vitality/vitality, mental health, social functionality, pain, general health perception). The scores of each sub-dimension and two main dimensions in the scale range from 0-100. The SF-36 with a positive score was scored in such a way that the higher the score of each health area, the higher the health-related quality of life (19).

Treatment Programs

Pulmonary Rehabilitation Program: During the treatment, all patient groups participating in the study were performed pursed-lip breathing in order to control dyspnea, improve ventilation and oxygenation, segmental breathing exercises to prevent accumulation of secretions, reduce paradoxical breathing and improve chest mobility, accompanied by a physiotherapist in the hospital. In addition, six different relaxation positions (high side lying, high lying on the back, leaning forward, loose sitting, leaning on the back, loose sitting, loosely sitting on the back, to reduce respiratory distress during diaphragmatic breathing and dyspnea attack) standing) was taught. Coughing and huffing, forced expiration technique and postural drainage positions that the patient will do at home were shown to the patients for easy removal of secretions. In addition, each patient was advised to perform 10 repetitions per hour with an intensive spirometer. In addition, the patients were trained to regularly perform the described physiotherapy methods twice a day (20).

Neuromuscular Electrical Stimulation (NMES): In addition to the pulmonary rehabilitation program, a total of 20 sessions of NMES were applied to the QF and GC muscle groups of the patients in the stimulation group 5 times a week for 20 minutes a day for 4 weeks. NMES application was performed by physiotherapists using the Cefar Compex Theta 500 device. In NMES application to the QF muscle, the negative electrode (5x7.5 cm) was placed 5-7 cm proximal to the

patella, and the positive electrode (5x7.5 cm) 10-12 cm distal from the inguinal region (21, 22). For the GC muscle, the negative electrode (5x7.5 cm) was placed proximal to the insertion of the Achilles tendon, and the positive electrode (5x7.5 cm) was placed approximately 3 cm below the popliteal fossa. Although there are limited studies in the literature, 100-200 µs transition time, 60 Hz and above frequencies were accepted as effective in amplification, so the frequency was 100 Hz and the transition time 200 µsec in this study (22, 23). In all NMES applications, patients were asked not to make voluntary contractions during the stimulation by taking the maximal tolerance as a criterion for increasing the flow intensity. In general, the flow intensity was increased at a rate that would cause contraction in the QF and GC muscle groups, but not cause discomfort in the patient.

Randomization and blinding

A randomization procedure was performed for 48 COPD patients. According to GOLD criteria, participants with stable COPD in group B were randomly divided into three groups as control, GC, and QF using randomization according to their age and gender. At baseline and after the treatment period of 4 weeks (20 sessions), all assessments were evaluated by the investigator (H.Ç), who was blinded to the groups throughout the study.

Ethical Committee

The study proposal was approved by the Research Ethics Board of Hitit University Faculty of Medicine (number: 2016-23), (ClinicalTrials.gov Identifier: NCT05501457).

Statistical Analysis

In this study, analysis of the normal distribution was performed using 5 parameters (Skewness-Kurtosis, Shapiro Wilk Test, P-P plots, Standard deviation/Mean and Histogram). Data that were considered to be normally distributed were considered parametric, and those that were not normally distributed were considered nonparametric. Parametric data were presented as Mean±Standard Deviation (Mean±SD). While the One Way ANOVA test was applied in multi-independent group analysis of parametric data, the tukey test was applied because the variances were homogeneous in posthoc comparisons (p>0.05). Related Samples T Test was applied for comparison of two dependent groups of parametric data. Non-parametric data were shown as Median (Minimum-Maximum). In the independent multi-group comparisons of nonparametric data, Kruskal Wallis H Test was used, and in post hoc comparisons, Bonferroni correction was made and Mann Whitney U test was applied. Wil-Coxon Sign Test was used for the comparison of two dependent groups of nonparametric data.

RESULTS

Of the 56 COPD patients admitted to the clinic, 48 (21 female, 27 male) met the inclusion criteria. After randomization, the study was started with 16 individuals with COPD in each group. However, one participant in each group could not continue the study due to disease exacerbation. The flow chart of the study is shown in **(Figure 1)**.

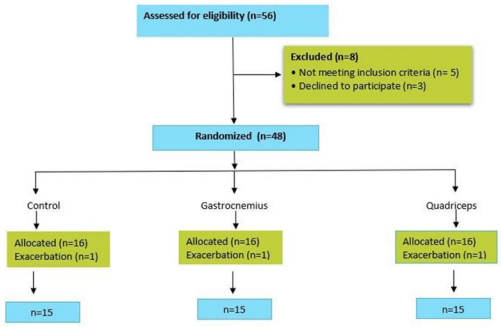

Figure 1: Flow diagram of the study

The mean age of the patients was 58.80±5.30 years in the GC group, 57.65±5.57 years in the QF group and 59.40±5.02 years in the control group. There was no statistically significant difference between the groups(p=0.499).The groups had similar sex ratios, body mass indexes and duration of COPD. While there was no significant difference in VAS values before and after treatment in the control group (p=0.669), there was a statistically significant difference in the GC and QF groups (p=0.007), (p=0.006). There was no significant difference between before and after treatment in all sub-parameter values of SGRQ tests in all groups (p=0.576, p=0.651, p=0.055). There was a significant difference between SF-36 score before and after treatment only in physical function sub-parameters in GC and QF groups (p=0.047). There was no

significant difference between before and after treatment in all other sub-parameter values of the SF-36 scale (p=0.043). While there was no difference between the control group (p=0.589) in the Beck Depression, six-minute walking and fatigue test before and after the treatment, there was a statistically significant difference in the GC and QF groups (p=0.048, p=0.030). There was no significant difference between the groups in the pre- and post-treatment values of all tests (p=0.682, p=0.888, p=0.217), **(Table 1)**.

Table 1: Comparison of COPD patients according to groups and within-group before and after treatment (*p<0.05. **p<0.01. ***p<0.001)

	Control Group (min-max)	GC Group (min-max)	QF Group (min-max)	Sig (p2)
Age (years)	59.40±5.02	58.80±5.30	57.65±5.57	0.499
Pre-treatment VAS	6 (2.50-8.50)	4.50 (3-8)	4 (2-8)	0.299
Post-treatment VAS	5.50 (1.50-10)	3 (2-7)a*	3 (1.50-6)a*	0.028
Sig. (p1)	0.669	0.007**	0.006**	
Pre-treatment SGRQ (Symptom)	350 (150-650)	550 (200-725)	475 (150-800)	0.104
Post-treatment SGRQ (Symptom)	375 (75-675)	550 (200-700)	375 (100-675)	0.136
Sig. (p1)	0.576	0.651	0.055	
Pre-treatment SGRQ (Activity)	900 (200-1500)	1100 (375-1500)	750 (375-1400)	0.427
Post-Treatment SGRQ (Activity)	825 (0-1750	1100 (400-1575)	650 (300-1750)	0.299
Sig. (p1)	0.754	0.753	0.043*	
Pre-Treatment SGRQ (Effect of Disease)	1550 (400-2600)	1800 (770-3600)	1500 (100-2650)	0.431
Post-treatment SGRQ (Effect of Disease)	1525 (100-2475)	1750 (750-3640)	1420 (150-2300)	0.248
Sig. (p1)	0.932	0.683	0.268	
Pre-Treatment SGRQ (Total)	2950 (275-4675)	3300 (1370-5400)	2950 (750-4850)	0.287
Post-treatment SGRQ (Total)	2625 (875-4650)	3225 (1325-5425)	2550 (650-4625)	0.168
Sig. (p1)	0.955	0.900	0.096	
Pre-Treatment SF-36 (Physical Function)	40 (0-100)	25 (5-75)	45 (0-100)	0.165
Post-Treatment SF-36 (Physical Function)	45 (5-100)	32 (10-75)	50 (20-90)	0.127
Sig. (p1)	0.479	0.047*	0.070	
Pre-Treatment SF-36 (Physical Role Difficulty)	50 (0-100)	30 (0-100)	50 (0-100)	0.281
Post-treatment SF-36 (Physical Role Difficulty)	50 (0-100)	40 (0-100)	60 (0-100)	0.166
Sig. (p1)	0.857	0.602	0.246	
Pre-Treatment SF-36 (Emotional Role Difficulty)	33 (0-100)	33 (0-66.60)	45 (0-120)	0.509
Post-Treatment SF-36 (Emotional Role Difficulty)	33.30 (0-100)	33.30 (0-100)	66.60 (0-100)	0.103
Sig. (p1)	0.655	0.859	0.074	
Pre-Treatment SF-36 (Energy / Vitality / Vitality)	45 (10-95)	40 (0-85)	45 (10-85)	0.604
Post-Treatment SF-36 (Energy/Vivacity/Vitality)	50 (10-100)	45 (10-85)	50 (30-100)	0.459
Sig. (p1)	0.694	0.717	0.276	
Pre-Treatment SF-36 (Spiritual Health)	60 (28-100)	52 (0-100)	56 (40-100)	0.623
Post-Treatment SF-36 (Spiritual Health)	60(16-92)	55 (15-110)	60 (32-92)	0.369
Sig. (p1)	0.244	0.148	0.285	
Pre-Treatment SF-36 (Social Functioning)	50 (0-100)	40 (0-100)	50 (0-100)	0.365
Post-Treatment SF-36 (Social Functioning)	42.50 (9-100)	40 (15-100)	60 (9-112)	0.321
Sig. (p1)	0.345	0.858	0.505	
Pre-Treatment SF-36 (Pain)	37.50 (22.5-100)	37.50 (0-100)	45 (0-100)	0.846
Post Treatment SF-36 (Pain)	45 (9-100)	40(10-100)	45 (10-120)	0.694
Sig. (p1)	1.000	0.330	0.169	
Pre-Treatment SF-36 (General Health Perception)	45 (20-90)	42 (15-110)	45 (0-100)	0.544
Post-Treatment SF-36 (General Health Perception)	55 (10-100)	45 (0-100)	60 (20-75)	0.483
Sig. (p1)	0.682	0.888	0.217	
Pre-Treatment Beck Depression Inventory	13 (2-61)	19 (3-43)	19 (2-32)	0.294
Post-Treatment Beck Depression Inventory	13 (3-42)	15 (7-35)	15 (6-25)	0.469
Sig. (p1)	0.589	0.048*	0.030*	
Pre-Treatment 6 Minutes Walk Test (Meter)	385 (250-465)	350 (230-550)	350 (100-465)	0.921
Post-Treatment 6 Minutes Walk Test (Meter)	375 (280-435)	375 (395-600)	380 (200-480)	0.735
Sig. (p1)	0.098	0.037*	0.020*	
Pre-Treatment Fatigue	4 (1-10)	4 (1-10)	4 (1-9)	0.802
Post-Treatment Fatigue	4 (0-10)	3 (0-7)	3 (0-8)	0.946
Sig. (p1)	0.476	0.049*	0.008*	

**Sig. (p1): Statistical value between in-group pre- and post-treatment data.*
**Sig. (p2): Statistical value of pre-treatment and post-treatment data between groups*
** VAS: Visual Analogue Scale*
** SGRQ: St. George's Respiratory Questionnaire*
** SF-36: Short Form 36*

DISCUSSION

In the present study, the effects of GC and QF muscles strengthened by NMES application on exercise performance and quality of life of COPD patients were evaluated. In patients with COPD, in GC and QF groups where GC and QF muscles were strengthened together with pulmonary rehabilitation; VAS, physical function, Beck depression, six-minute walking distance and post-exercise fatigue were improved compared to the pulmonary rehabilitation group. However, GC and QF groups were not superior to each other. We think that it is important to strengthen the QF and GC muscles separately or together with pulmonary rehabilitation for exercise performance and quality of life in individuals with COPD.

Although QF is the sole muscle that undertakes the extensor mechanism of the knee, it also contributes to the stability of the patella. It has a large cross-sectional surface area and can shorten by about 8 cm when contracted (9). The QF muscle has an important role in static and dynamic aspects. Its static role is to prevent knee flexion while standing. Its dynamic role is to provide strong knee extension as in jumping and running exercises (24). Adequate lower extremity muscle strength is needed to perform many daily living activities such as sitting, standing, walking and climbing stairs. QF weakness is associated with decreased activities of daily living and risk of falling (25). In the present study, it was observed that COPD patients whose QF muscle was strengthened with the NMES method increased in their daily living activities. These results show how important the QF muscle is in the activities of daily living and the lower extremity muscle that should be the first focus in the treatment of COPD patients is the QF.

Kamiya et al. (24) measured QF muscle strength with a hand dynamometer and exercise capacity as MET with the treadmill exercise test in their study on 621 coronary artery disease patients. As a result of their study, maximum QF muscle strength was found to be associated with exercise capacity in patients with coronary artery disease. QF muscle strength was found to be a strong predictor of exercise capacity. In the study, it was observed that physical function and walking distance increased, and the level of fatigue after exercise decreased in COPD patients whose QF muscle was strengthened. The study findings were found to be compatible with the literature.

The GC muscle plays an important role in actions such as walking and running by pushing the surface. In this way, it is directly related to the individual's gait and overall performance (10). The GC muscle is one of the most important locomotor muscles of the body, which has two parts, bipennate, biarticular, medial and la-

teral, which are effective in both the knee and ankle joints (26). Lamontagne et al. reported that there is a negative correlation between gastrocnemius muscle spasticity severity and walking speed in stroke individuals (27). The gastrocnemius muscle is a biarticular muscle. One of the advantages of biarticular muscles is the transfer of power from the proximal to the distal joints (28). For this reason, it is suggested that the effects of biarticular muscles on the body should be considered as a whole, not only on the joints they spread (29). In the study, it was observed that COPD patients whose GC muscle was strengthened with pulmonary rehabilitation had improvements in VAS, walking distance and fatigue levels compared to COPD patients who received only pulmonary rehabilitation. From these results, we can say that the weakness of the GC muscle in patients with COPD impairs the pushing phase of walking, then walking and finally exercise performance. In the study, it was observed that COPD patients whose GC muscle was strengthened with pulmonary rehabilitation had improvements in VAS, walking distance and fatigue levels compared to COPD patients who received only pulmonary rehabilitation. With these results, we can say that the GC muscle is weak in patients with COPD, and that walking at first disrupts the pushing phase, then walking and finally exercise performance. We believe that the GC muscle is one of the muscles that should be considered in the treatment of COPD.

In a randomized controlled double-blind study, Bourjeily-Habr et al., found significant improvement in the maximum strength of the quadriceps and hamstring muscles and a distance increase in the progressively increased shuttle walking test in stable outpatients with poor baseline exercise tolerance, low respiratory reserve, and severe COPD who were trated with NMES versus the placebo-treated group. In that study NMES was applied to the quadriceps, hamstring, and gastro-soleus muscles. But did not report any significant changes in lung function, peak workload, or peak oxygen consumption in either group (30). In the present study, physical function and walking distance increased in the GC and QF groups compared to the control group. It was observed that the level of pain and fatigue felt by the COPD patients in the GC and QF groups decreased even more than in the control group. All these results suggest that exercise performance in COPD patients is affected by weakness in the lower extremity muscles as well as lung dysfunction, and strengthening the GC and QF muscles in COPD improves exercise performance and quality of life.

In the study of Neder et al. in COPD patients with severe respiratory distres; the treatment group that recieved NMES to the QF muscles for 6 weeks, maximum isokinetic strength of the QF muscle was significantly improved, muscle fatigue was decreased, and exercise-related dyspnea was improved compared to the control group. It has been shown that it causes an increase in the exercise capacity together with daily life activity (31). Another study revealed that patients with malnourished COPD and patients with low endurance following hospitalization due to COPD showed greater improvement in QF muscle strength and dyspnoea during daily activities after 4 weeks of NMES treatment applied to the QF muscle compared to the control group (12). Again, in a double-blind placebo-controlled study involving NMES treatment applied to the QF muscle of patients with advanced COPD, it was shown that NMES increased the functional exercise capacity of patients by strengthening the QF muscle (32). In their study, Vieira et al. divided 20 COPD patients into two groups, they reported that there were significant improvements in pulmonary function tests, borg scale and quality of life in the group in which NMES was applied to both quadriceps muscles (33). Our study is the first to compare lower extremity muscles in COPD using NMES. There were significant improvements in VAS, physical function, Beck depression scale, six-minute walking test, and post-exercise fatigue in the group in which NMES was applied to the QF muscle. Similar results were obtained in the group in which NMES was applied to the GC muscle as well as the group that was applied NMES to the QF muscle. Although the literature shows the importance of the QF muscle in increasing the exercise capacity, the study shows that the GC muscle is as important for the exercise capacity and quality of life as the QF muscle.

The limitations of our study are the lack of long-term follow-up of COPD patients. In addition, unlike the literature, the fact that it was performed in patients with stable early stage COPD is among our limitations.

In conclusion, strengthening of the QF or GC muscle together with pulmonary rehabilitation has a positive effect on treatment in individuals with stable COPD. However, no superiority was observed between these two groups. Strengthening the QF or GC muscle together with pulmonary rehabilitation or both muscle groups together with pulmonary rehabilitation can be added to the treatment. It may be a useful method for maintaining or improving the conditioning of peripheral muscles during acute exacerbations of COPD or any disease that may interfere with regular exercise training in this population. Considering all these data, we can say that strengthening the QF or GC muscle with pulmonary rehabilitation in COPD increases exercise performance and quality of life more.

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