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Effectiveness of Quadriceps Muscle Strengthening in Chronic Obstructive Pulmonary Disease - A Randomized Controlled Trial

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Keywords:

Chronic Obstructive Pulmonary Disorder, Quadricep, one-repetition maximum, 6-min walk distance, Manual muscle testing

Abstract

Background: COPD is a crippling and progressive respiratory condition that frequently causes considerable muscular atrophy, especially in the quadriceps. Weakness in the quadriceps has been associated with decreased muscle strength which may result in poor quality of life, and a rise in reduced mobility due to the risk of fractures and falls in COPD patients.

Methods: Thirty-five patients diagnosed with COPD irrespective of gender, over the age of 45 and less than 60 years were recruited for the study. Patients were divided into control and experimental groups and exposed to five weeks of guided quadriceps muscle-strengthening exercises. VMO (Vastus Medialis Oblique) exercises and progression exercises were added to static and dynamic quadriceps exercises for the experimental group. Pre-test and post-test quadriceps muscle strength were assessed using a 6-min walk distance (6MWD), one-repetition maximum (1RM) and Manual muscle testing (MMT). Data were analyzed using SPSS software.

Results: Mean age of male COPD patients was 56 and 54.5 years respectively for the control and experimental groups. There was a statistically significant improvement in quadriceps muscle strength of the experimental group was noted by analyzing 1RM and MMT test data. 6MWD test results showed statistically significant improvement in quadriceps muscle capability to walk for the experimental group. Hence an improvement in daily living activities was considered as a result of engaging VOM and progression exercises in the conventional physiotherapy exercise program.

Conclusion: Quadriceps strengthening exercises are effective in improving pain , function , and quality of life in patients with COPD.

1. Introduction:

More than 212.3 million people suffer from Chronic Obstructive Pulmonary Disorder (COPD), one of the most widespread chronic illnesses in the world[1]. Around 3.23 million people die in the world each year from COPD, the third most common killer[2]. It is a lung illness that worsens with time and makes breathing challenging. Shortness of breath is the main sign of COPD. Chest tightness, wheezing, and coughing are further symptoms[3].

The one-repetition maximum (1-RM) strength test is defined as the maximal weight that can be lifted once by proper lifting technique using a resistance machine. It can lead to a loss of muscle strength and a fall in lung function[4]. One of the most important muscles for persons with COPD is the quadriceps, which provide stability during walking and stair climbing and support

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the knee joint[5]. Although there is no cure for COPD, there are medicines that can help manage the disease's symptoms and its progression[6]. Strengthening the quadriceps is one form of treatment [6, 7]. Exercises that target the muscles in the front of the leg can strengthen the quadriceps. These workouts can increase the stamina and strength of the legs. Moreover, they can enhance walking speed and lessen shortness of breath [7, 8].

The one-repetition maximum (1-RM) strength test is commonly used for strength assessment of people. It is defined as the maximal weight that can be lifted by using a resistance machine The 1-RM is regarded as the gold standard for determining muscular strength outside of a lab [9]. The 1-RM test has recently been utilized to examine the muscle strength assessment in people with COPD. The test does, however, necessitate trained personnel and equipment, as well as an unavoidable time commitment that may hinder its broad usage in healthcare settings. In the majority of clinical settings, including physiotherapy clinics, it is used as a quick and simple technique to generate valid and reliable muscular strengthening results [10, 11].

Field walking tests are frequently used to assess exercise ability, determine the prognosis, and gauge how well a treatment is working [12]. A lot of new material relevant to the administration of the 6-min walk test (6MWT) has emerged in recent years, and the body of information describing the strength of quadriceps based on 6MWT is also available [12, 13, 14].

This article will explore the effectiveness of quadriceps muscle strengthening exercises in people with COPD as an intervention to improve physical activity levels. We will examine current evidence and discuss how these exercises can help reduce symptoms associated with COPD.

2. Methodology

Subjects

A random sample of 35 patients that visited the Physiotherapy Department, …… Hospital, Krishna Vishwa Vidyapeeth University, Karad, Maharashtra, India for quadriceps muscle weakness with COPD problems were selected in the study. Both Male and female patients of the age group 45-60 years, with COPD were enrolled for the study. Exclusion criteria were a significant cardiac disease, diagnosis of cancer, neuromuscular or neurological disorders, severe arthrosis, or other musculoskeletal limitations that lessened the testing procedures or exercise training. Patients which were not interested in the study were also excluded. Written informed consent was obtained from all patients included in the study. The study protocol was approved by the ethics committee of the hospitals.

Study design

Based on inclusion-exclusion criteria, 32 patients were included in the study. Patients included in the study were randomly divided into two groups: control and experimental. Both groups received therapy five weeks of guided therapy for three times per week. To prevent subject interaction between the groups, the treatment was given to the experimental group on Mondays, Wednesdays, and Fridays while the control group received treatment on Tuesdays, Thursdays, and Saturdays. All patients followed the quadriceps strengthening exercise program. It included static quadriceps, dynamic quadriceps exercises for the control group and VMO (Vastus Medialis Oblique) exercises, and progression exercises in addition to static and dynamic quadriceps for the experimental group. Before and after the training program, pre-test and post-test evaluation of 6-min walk distance (6MWD) and one-repetition maximum (1RM) and Manual muscle testing (MMT) were conducted for patients.

Walking capacity test: The American Thoracic Society (ATS) 6MWT standard was used to assess the walking ability of patients. All patients completed the 6MWT as directed by the ATS in a 40 m indoor, level hospital corridor under the guidance of a physiotherapist. Before the walk, each patient received the same instructions, and the physiotherapist cheered them on by repeating predetermined phrases every minute. Throughout the test, the distance traveled was measured in meters. Throughout the test, patients could stop and take a break, but they were told to start walking again as soon as they were ready to do so [15].

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1-RM test: A resistance weight-lifting machine was used for the 1-RM strength test. All patients were given instructions on the right technique before the muscular strength test. Each subject was given brief instructions to simultaneously extend both knees from a 90° knee flexion position to a 180° extension while sitting. This exercises the quadriceps and other thigh muscles. All participants underwent two load-free familiarization sessions before the 1-RM testing sessions. With a random initial load that was increased or decreased in accordance with the individual's ability to perform a repetition, the goal of this 1-RM strength test was to determine the most weight that the person could move in a single repetition; this could be repeated again with a 1-minute rest period [16].

Manual muscle testing: Patients were instructed to side lye while supporting themselves with the supporting limb. Flexing the lower limb can increase stability. Hold the test limb with the hip fully extended and the knee flexed to roughly 90 degrees. The therapist is positioned at knee level behind the patient. Test limb is held in place around the thigh by one arm, with the hand supporting the kneecap. Another hand supports the leg just above the ankle. The patient was instructed to extend their knee to its full range of motion, and the therapist neither helped nor hindered them [17]. The patient's muscle strength was graded on 5 point scale with grade 1 meaning no movement and grade 5 meaning can hold test position against pressure. The sum of all patient scores is multiplied by twenty to determine the total score out of 100. The greater a score of each group defines lower muscle strength in patients.

Statistical analysis: Mean (M), standard deviation (SD), and t-test were calculated using SPSS software to assess the difference between pre-test and post-test data for walk test, 1-RM and muscle strength. The level of significance was taken as 5%, which means $p < 0.05$ indicates significant and $p > 0.05$ is not significant.

3. Results

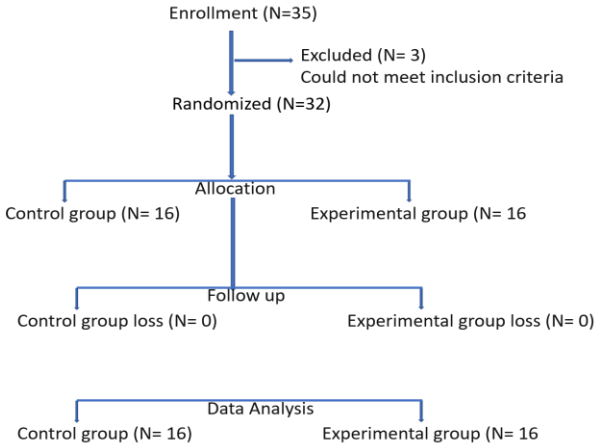

Figure 1: Flow chart of study design

Table 1: Gender distribution in Control and Experimental Groups

Gender	Control Group (Percent)	Experimental Group (Percent)
Male	6 (37.5%)	7 (43.75%)
Female	10 (62.5%)	9 (56.25%)
Total	16 (100%)	16 (100%)

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Table 2: Comparison of age and BMI between Control and Experimental Groups

Comparison	Gender	Control Group	Experimental Group
Mean age (years)	Male	56.0	54.5
	Female	51.5	49.5
Mean BMI	Male	31.6	29.2
	Female	32.0	32.5

Table 3: Pre-test and post-test comparison of 6MWD and 1RM in Control and Experimental Groups

Sample		Pre-test			Post-test			p-value
Subjects	Test	Mean	SD	Range	Mean	SD	Range	
Control group	6MWD	295	5.43	5.0 - 8.8	305	5.90	275 – 317	> 0.05
	1RM	18.85	1.04	16.2 – 21.2	19.30	1.05	15.9 – 22.0	> 0.05
Experimental Group	6MWD	302	6.30	5.2 – 9.0	345	6.60	285 – 336	< 0.05
	1RM	17.34	1.05	16.5 - 19.2	23.95	0.91	20.0 – 26.5	< 0.05

Table 4: Pre- test and post- test comparison of muscle strength in Control and Experimental Groups

Sample	Pre-test			Post-test			p-value
	Mean	SD	Range	Mean	SD	Range	
Control group	68.50	6.50	52.0 - 88.8	62.20	5.20	52.5 – 62.0	> 0.05
Experimental group	65.30	7.50	56.2 – 85.2	43.30	7.05	35.0 – 54.5	< 0.05

A total 35 subjects were enrolled for the study. Three subjects who could not meet the inclusion criteria were excluded from the study. 32 subjects were randomly divided into two groups: Control and experimental. All subjects completed the procedures without any dropouts (Figure 1).

Demographic data were collected and analyzed. The percentage of male and female subjects in the control group was 37.5% and 62.5 in the control and 43.75% and 56.25% in the experimental group respectively. The average age of subjects the control group and experimental group were 56.0 and 54.5 years respectively. Female subjects of the control group and experimental group were of comparatively lower weight, 51.5 and 49.5 years respectively. The BMI of male subjects of the control group and experimental group were 31.6 and 29.2 respectively. Female subjects of both the control and experimental group had similar BMI, 32.0 and 32.5 respectively (Table 2).

Pre- test and post- test data of the 6MWD test showed a significant difference in distance traveled by the experimental group. A statistically significant increase in weight lifted by subjects of the experimental group was noted in the 1RM test. was noticed after two weeks of treatment in both groups. No significant

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improvement was found for 6MWD and 1RM test in control group (Table 3).

Changes in muscle strength were measured manually by comparing pre-test and post- test data. A significant change in the strength of the quadriceps was noticed in the experimental group only (Table 4).

4. Discussion:

The present study found that the VMO exercises and progressive resistive exercise along with conventional therapy resulted in a significant improvement in muscle strength (1RM and MMT for Quadriceps), and functional capacity (6MWD). A statistically significant added effect on the overall strength and capability of subjects was noted after VMO and progressive exercises as compared to conventional therapy alone.

Skeletal muscle dysfunction is known to be a prevalent symptom of COPD patients and may significantly contribute to morbidity and mortality [18]. Exercise capacity is closely related to lung function, which is the reason why COPD patients prevent aerobic exercises [19]. Skeletal muscle dysfunction along with inflammation, low levels of anabolic hormones, and reactive oxygen species is probably caused by nutritional deficiencies, age, and hypoxia in COPD patients [20, 21]. Patients with COPD have higher levels of pro-inflammatory cytokines, which usually results in muscle atrophy [21, 22]. These might be responsible for the reduction in quadriceps strength in COPD patients. Thus, quadriceps muscle strengthening exercises with VOM and progressive resistance exercises, may promote muscle strength and reduce muscle stiffness. The current study's 1RM and MMT results reveal a considerable increase in muscular strength and capability. Furthermore, COPD patients with the worst airway obstruction were shown to have the highest prevalence of quadriceps weakening as measured by isometric quadriceps maximum voluntary contraction strength [23, 24]. Moreover, strength training causes less dyspnea during exercise than aerobic training, making it more tolerable [25, 26]. The results of the present study may be a useful example for the rehabilitation of patients with COPD.

5. Conclusion:

Quadriceps strength measured by a 6MWD, 1RM, and MMT is useful in predicting the better daily life of patients with COPD. Five weeks of guided quadriceps strength training with VMO and progressive exercises were found very effective in improving strength, functional capability, and self-reported health in patients with COPD.

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