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Research Article

Chronic Obstructive Pulmonary

Hand Grip Strength As A Marker of Functional Impairment In Chronic Obstructive Pulmonary Disease Patients

Neena RS[1*], Fathahudeen A[2], Kamala R[3]

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[1*] Neena RS, Postgraduate Resident, Department of Respiratory Medicine, Government Medical College, Trivandrum, Kerala, India.
[2] Fathahudeen A, Professor and Head of the Department, Department of Respiratory Medicine, Government Medical College, Trivandrum, Kerala, India.
[3] Kamala R, Assistant professor, Department of Respiratory Medicine, Government Medical College, Trivandrum, Kerala, India.

Background: COPD is a heterogeneous lung disease with multisystem involvement. COPD patients not only suffer from respiratory function impairment but also from peripheral muscle dysfunction which is an important manifestation that hinders day-to-day activities. Patients with a reduction in muscle strength should be detected early so that an early intervention through pulmonary rehabilitation can be done. pMDIs which is a common inhalation device in COPD require adequate hand strength for its actuation making the upper limb muscle strength an important parameter which is often ignored in COPD patients.

Objectives: To determine the hand grip strength of COPD patients objectively. To determine the association between hand grip strength with FEV1,6-minute walk distance and BODE index.

Methods: This is a cross-sectional followed by a prospective observational study conducted in the Department of Respiratory Medicine, Government Medical College, Trivandrum, Kerala. In 72 COPD patients, hand grip strength was assessed using a Camry Digital Dynamometer and was compared with the age and gender-adjusted values. Spirometry was done in all 72 patients and FEV1 measurement was recorded. A 6-minute walk distance was determined; the BODE index was calculated in these patients which comprises BMI, FEV1, Dyspnea on the MMRC scale and distance walked in 6 minutes.

Results: COPD patients were found to have a reduction in their hand grip strength compared to their age and gender-adjusted values. In COPD patients, hand grip strength was found to have a positive correlation with a 6-minute walk distance whereas grip strength was found to have a negative correlation with BODE INDEX.

Conclusion: Hand grip strength is impaired in COPD patients and it could be used as a marker of functional impairment.

Keywords: Hand Grip Strength, COPD, FEV1, BODE Index

Corresponding Author

Neena RS, Postgraduate Resident, Department of Respiratory Medicine, Government Medical College, Trivandrum, Kerala, India.
Email: neenakrishna1@gmail.com

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Introduction

Chronic Obstructive Pulmonary Disease is a heterogeneous lung condition characterized by chronic respiratory symptoms that cause persistent, often progressive airflow obstruction [1]. COPD is a multi-morbid condition and is one of the leading causes of disability and one of the top three causes of death worldwide, of these deaths, 90% occur in low- and middle-income countries[2][3].

COPD patients suffer from peripheral muscle dysfunction and atrophy which is due to active airway inflammation that leads to systemic inflammation in the form of elevated pro-inflammatory cytokines and increased levels of free radicals causing oxidative stress in systemic circulation. Skeletal muscle dysfunction is an important manifestation since it hinders day-to-day activities and can contribute to exercise intolerance and poor health status in patients with COPD.

In 1992, Killian and colleagues described skeletal muscle dysfunction in COPD patients and after that, a study by Hamilton and colleagues showed that 70% of COPD patients had lesser muscle strength compared to healthy participants [4][5]. In COPD patients, reduction in skeletal muscle strength, endurance and muscle mass, arises from various structural and metabolic factors such as hypoxia, disuse, changes in fibre type, bioenergetics, imbalance between muscle protein synthesis and degradation, and use of systemic steroids. COPD patients mostly accept a sedentary lifestyle to avoid the dyspnea on exertion thus worsening their sarcopenia. The severity of airflow obstruction correlates with the presence of malnutrition since ventilator inefficiency increases daily energy requirements. The imbalance of decreased oral intake and increased energy expenditure can lead to a negative nitrogen balance and decreases in skeletal muscle mass and function in COPD patients.

Importantly, skeletal muscle dysfunction is a modifiable form of exercise intolerance by rehabilitation [6]. Therefore, COPD management should include a rehabilitation programme which must include active exercise training that leads to a better quality of life by improving dyspnea and muscle strength. Hence early detection of the reduction of muscle strength aids in early intervention through pulmonary rehabilitation.

Muscle strength assessment of COPD patients is frequently done in lower limbs utilizing a 6-minute walk test which is an easy test and has a prognostic value in patients with COPD. Hence, upper muscle strength is often ignored many a times, but effective inhalational therapy in COPD requires not only adherence but also proper inhalation technique, which may not be correctly operated due to reduced hand strength. Hence upper limb muscle strength is crucial in COPD patients for proper inhaler use and preventing further exacerbations. In this context, we hypothesize that upper limb muscle strength is reduced in COPD patients along with a reduction of 6 MWT and FEV1.

Methodology

The study was conducted in the Department of Pulmonary Medicine, Govt. Medical College Thiruvananthapuram. This is a cross-sectional prospective observational study that included patients diagnosed with chronic obstructive pulmonary disease.

Inclusion Criteria:

- Patients diagnosed to have Chronic obstructive pulmonary disease clinically and confirmed with spirometry.

Exclusion Criteria:

- Patients presenting with acute exacerbation of COPD, Cor pulmonale (clinically unstable patients)
- Patients with neuromuscular diseases
- Patients with skeletal deformities, bone and soft tissue injuries of upper and lower limbs
- Patients who were not willing to participate.

Study Period: One and half years from the date of ethical clearance.

Sample Size:

The sample size was calculated from the formula

$$N = [(Z_{\frac{\alpha}{2}})^2 \sigma^2] / d^2$$

$Z_{\frac{\alpha}{2}}$ is 1.96 at 5% significance level; σ is 21.8 kg

D is an absolute precision of 0.5

Where **N=72**

As per the reference study "Upper limb muscle strength & endurance in chronic obstructive pulmonary disease." by Shah S, Nahar P, Vaidya S, Salvi S(7)

Sampling Method

Patients were selected by consecutive sampling methods, till the sample size was reached and the recruitment of patients satisfied inclusion and exclusion criteria.

Study Variables

- Sociodemographic variables
- Smoking status
- A comprehensive examination was done to determine the severity of COPD by a 6-minute walk test, BODE index and hand grip strength measurement.

Study Definitions

- Hand grip strength of COPD patients was compared with the age and gender-adjusted values.

Data Collection Tool

- Data were collected in a semi-structured questionnaire after taking informed consent.

Data Collection Technique: After obtaining informed written consent, patients of chronic obstructive pulmonary disease meeting the inclusion criteria attending the OPD of the Department of Pulmonary Medicine, Government Medical College Thiruvananthapuram were enrolled in the study. These patients were interviewed, and demographic characteristics and clinical history were noted. Vitals were checked and baseline blood investigations were documented.

A spirometry with a computerized spirometer was done on the same visit, and the values of all indices were noted. They were then instructed to do a 6MWT according to ATS guidelines and the hand grip strength of patients was assessed in the same setting using a hand grip dynamometer.

Spirometry: Spirometry was performed as per Joint Indian Chest Society- National College of Chest Physicians guidelines for spirometry. The parameters measured were forced expiratory volume in 1 sec (FEV1), forced vital capacity (FVC) in litres, and FEV1/FVC. Spirometry was done while the patient was seated in a chair,

The patient's mouth tightly fitted with a mouthpiece of the spirometer, following 3-4 tidal respiration patients were asked to exhale as much as possible followed by deep inspiration.

6-Minute Walk Test: 6 Minute Walk test (6MWT) was done according to ATS guidelines; the patient was asked to walk on a flat surface usually in a corridor 40 m long stretch. The patient was told to walk at his/her own pace and was advised to rest if the patient developed dyspnea, then again resume the test as soon as possible and time was monitored using a stopwatch. After the completion of 6 minutes, the total distance was measured in meters.

Hand Grip Strength Measurement: Hand grip strength was measured by using the CAMRY Digital Hand Scale – USA(FIGURE 1). Maximum hand grip strength was measured in the dominant hand. The patient was seated with his shoulder adducted and neutrally rotated, elbow flexed to 90°, and the forearm, and wrist in neutral position and the instrument supported with thigh. During measurement minimum of three trials of hand grip strength was measured with each 1-minute interval and maximum strength in kg was taken for calculations.

Since, normal hand grip strength for an individual is a range of values and differs according to a particular gender and age group(FIGURE 2 &3), for comparison, percentage is found to be a better tool than mean value.

$$Hand\ grip\ strength\ percentage = \frac{measured\ hand\ grip\ strength}{lowest\ value\ of\ normal\ range} \times 100$$

Gold Stages And Prognostic Index: GOLD stage calculated using predicted FEV1 percentage (TABLE 1)

Bode Prognostic Index: BODE prognostic index was calculated using Body mass index(B), airflow Obstruction (O), Dyspnea by mMRC scale (D) and exercise capacity as distance walked during 6 MWT (E) (TABLE 2).

Data Analysis: All the data were entered in an Excel spreadsheet and analysed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and the level of significance was set at p-value < 0.05. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. The normality of the data was assessed using Shapiro Wilkinson test. Pearson correlation test was done to find out the correlation.

Ethical Considerations

- Informed written consent was obtained from the patients.
- Confidentiality of subjects was maintained throughout the study.
- No financial burden was imposed on subjects.
- The study was commenced only after receiving approval from the institute's research committee & institution ethics committee.

Results

The mean hand grip of COPD patients was found to be18.024 kg±6.05, whereas, the mean hand grip strength in males is observed to be 19.7±5.57 Kg and in females, it is 11.62±2.44 kg. Our study demonstrates that both hand grip strength and hand grip strength percentage show significant positive association about 6 min walk distance (r=0.72; p=0.0001 and (r=0.69;p=0.0001) and significant negative correlation about BODE INDEX (r=-0.68; p=0.0001 and r=-0.75and p=0.0001), while GOLD stages which indicate the airflow limitation(FEV1) did not show any correlation with hand grip strength but showed significance with hand grip strength percentage(r=-0.37 and p=0.001). Thus it is observed that, with a reduction in hand grip strength, there is a reduction in 6-minute walk distance which concludes that hand grip strength may also be used to assess the functional status of COPD patients. It is also observed that hand grip strength reduction is more in patients with a higher BODE index which implies that, hand grip strength correlates with the disease severity.

Table 1: Airflow Limitation (Gold Stages)

POST BRONCHODILATOR FEV1/FVC <0.7		
GOLD 1	Mild	FEV1 ≥ 80% predicted
GOLD 2	Moderate	50% ≤ FEV1 < 80% predicted
GOLD 3	Severe	30% ≤ FEV1 < 50% predicted
GOLD 4	Very severe	FEV1 < 30% predicted

Table 2: Variables And Point Values Of Bode Index

VARIABLE	POINTS ON BODE INDEX			
	0	1	2	3
FEV (% OF PREDICTED)	≥65	50–64	36–49	≤35
DISTANCE WALKED IN 6 MIN (M)	≥350	250–349	150–249	≤149
MMRC DYSPNEA SCALE	0–1	2	3	4
BODY-MASS INDEX	>21	≤21		

Table 3: Correlation Analysis- (Hand Grip Strength Vs Variables)

	r value	P value
6 MIN WALK DISTANCE	0.72	0.0001*
BODE INDEX	-0.58	0.0001*
GOLD STAGE	-0.21	0.07

Table 4: Correlation Analysis- (Hand Grip Percentage Vs Variables)

	r value	P value
6 MIN WALK DISTANCE	0.69	0.0001*
BODE INDEX	-0.75	0.0001*
GOLD STAGE	-0.37	0.001*

Discussion

COPD is a heterogeneous disease and is one of the major causes of morbidity and mortality especially in low- and middle-income countries. Multimorbidity in COPD is identified as an important modifiable factor, which when detected early can help in reducing the disease burden. .

One of the systemic manifestations of COPD is skeletal muscle dysfunction and one of its components is hand grip strength, in our study, it is hypothesized that hand grip strength is reduced in COPD patients and here we made an attempt to analyse various significant parameters in COPD.

In our study, 72 COPD patients attending Pulmonary Medicine OPD were selected and found out that 57 patients were males i.e., 79.2% of the study population is males and 15 patients were identified as females i.e., 20.8%..

The higher prevalence of COPD in males detected by our study is not only due to the higher prevalence of COPD reported in males, especially in low and middle-income countries[8], but also because the diagnosis of COPD is more confidently done in males compared to females.

Socioeconomic status (SES) is one of the important determinants of health across various chronic diseases. Lower SES was found to be associated with greater COPD morbidity and mortality [9]. In our study, 47 among 72 COPD patients belonged to the socioeconomic status of below the poverty line which comprises a majority of about 65.3% of the total study population. Regarding the etiology of COPD, the leading causes of COPD worldwide are tobacco smoking and exposure to household air pollution from biomass fuels,

Although in low- and middle-income countries, the most common cause is tobacco smoking [10], which is substantiated by our study revealing that 58 out of 72 patients, which is almost 80 % of the patients, are smokers and almost 19 patients had exposure to biomass fuel where the majority are females.

Besides these, COPD may also be caused by other inciting triggers like a prior history of tuberculosis, which is quite commonly found in a tuberculosis-endemic country like India and it is observed that 27.8% of our study participants had a history of tuberculosis infection.

Various systematic reviews and meta-analyses reveal that the prevalence of COPD is higher in males, aged≥ 40 years and smokers. A total of 17 observational studies involving 30,182 COPD patients found a significant nonlinear relationship between BMI and mortality of COPD patients and they found that COPD patients with a BMI of <21.75 kg/m2had higher mortality rates.

Moreover, an increase in BMI resulted in a decrease in the risk of death. The risk of death was lowest when BMI was 30 kg/m2(RR = 0.69; 95% CI, 0.53–0.89). Thus, in COPD patients variables like gender, age, and BMI have significance in their prevalence and mortality rates. In our study, the descriptive analysis of participant characteristics like age, height, weight and BMI was done. Participants ranged from 50 to 85 years old, with a mean age of 66.13 years with SD of 7.18.

Height ranged from 134 cm to 174 cm, with a mean height of 159.32 cm with SD of 9.22. Weights ranged from 37 kg to 95 kg, with a mean weight of 56.44 kg with an SD of 12.11. Body Mass Index ranged from 13.40 to 44.00 kg/m², with a mean BMI of 22.19 kg/m² (SD = 5.26), which accounts for the Biomass index (B) in BODE index.

As suggested by the definition, COPD is a disease of persistent, often progressive airflow limitation and the diagnosis of COPD has to be established only after spirometry, which should follow the criteria of post broncho dilator FEV1/FVC ratio of ≤ 0.70. Hence, spirometry is an unavoidable tool in diagnosis as well as in monitoring airflow limitations in COPD patients.

On that note, patient selection in our study was done only after confirmation with spirometry, rather than relying on a history of exposure like tobacco or biomass fuel and symptoms alone.

Spirometry is done for all 72 patients and they are categorized into various GOLD stages based on their FEV1 value. It is observed in our study that, 12.5% (n=9) belonged to GOLD stage I (mild), 33.3% (n=24) in GOLD stage II (moderate), 30.6%(n=22) in GOLD stage III (severe), and 23.6%(n=17) in GOLD stage IV (very severe), and this accounts for the airflow obstruction (O) in BODE index.

The most common and characteristic symptom of COPD is chronic dyspnea along with cough, wheezing and chest signs [1]. In our study, it was found that the majority of the patients reported their chief complaint as dyspnea, 37 participants constituting 51.4% reported dyspnea as their chief complaint while 10 participants (13.9%) reported cough, and 25 participants (34.7%) reported to experience both dyspnea and cough as their main symptom.

In the background of dyspnea as the profound symptom of the majority, 4 among the 72 study participants i.e., 5.6% had dyspnea of Grade I MMRC (modified Medical Research Council), whereas, 32 patients i.e., 44.4% reported having Grade II MMRC. Additionally, 30 participants (41.7%) were found to have Grade III MMRC, and 8.3%(n=6) had Grade IV MMRC, thus accounting for the Dyspnea (D) in the BODE index.

The 6-minute walk test (6MWT) may be used as a tool to assess COPD patients and can be used to evaluate the exercise capacity and functional status of COPD patients. It is simple to perform and correlates well with more advanced tools for the evaluation of exercise capacity. It can also be used for evaluating the outcome of pulmonary rehabilitation.

In a study done by Dajczman E, Wardini R, et al in 237 patients with severe COPD, mean (± SD) for FEV1 was 0.75±0.36 L, while mean survival of COPD patients on follow-up for the study period as per predefined categories of 6MWD of ≥250 m, 150 m to 249 m and ≤149 m was 42.2, 37.0 and 27.8 months (P<0.001), respectively, with a three-year survival of 81%, 66% and 34% observed, respectively.

In the group with a shorter 6minute walk distance, early mortality was significantly higher, especially for those patients who did not have minimal improvement with pulmonary rehabilitation from their study they concluded that older age,

Male sex and shorter 6MWD in the initials setting were negative predictors of survival in COPD patients(11) thus, emphasizing the importance of 6MWD in COPD patients. While considering 6-minute walk distance (6MWD) of participants in our study, among the total sample of 72 participants, it is found that 13.9%(n=10) had 6MWD of 350 meters or more, 27.8%(n=20) had 6MWD between 250 and 349 meters, 48.6%(n=35) between 150 and 249 meters, and 9.7%(n=7) achieved 149 meters or less.

This accounts for the exercise tolerance (E) in the BODE index. The BODE index is an identified prognostic tool in COPD. The BODE index is categorized from scores of 0 to 10 based on Body mass index (B), airflow Obstruction (O) by FEV1, Dyspnea (D) by MMRC scale, and Exercise capacity (E) using a 6-minute walk distance.

In a study conducted by *Kamath S et al*, on the correlation of BODE index with quality of life in sixty stable COPD patients, according to BODE score, (n=16) 26.7% of patients were categorized to have BODE 1, (n=27) 45% BODE 2, (n=15) 25% BODE 3 and (n=2) 3.3% were BODE 4.

Very strong correlations were found between BODE quartiles and total SGRQ (St. George's Respiratory Questionnaire (SGRQ) to assess the health-related quality of life) scores (P< 0.01). Among the components of BODE index, the decrease in the FEV1 (%predicted) and 6MWD, and the increase of MMRC dyspnea grade were associated with worsening of health status (increase in total SGRQ and SGRQ subscales) and BODE index was also correlated with the acute exacerbations (P< 0.0012) during one-year follow-up [12] In our study, BODE index scores among 72 participants, are distributed as follows: BODE 1 (1.4%), BODE 2 (9.7%), BODE 3 (15.3%), BODE 4 (8.3%), BODE 5 (16.7%), BODE 6 (11.1%), BODE 7 (18.1%), BODE 8 (13.9%), and BODE 9 (5.6%) and BODE 10 (0%).

In our study, the main variable under study, i.e., hand grip strength analysis which is done using a hand grip dynamometer among study participants is categorized as Normal and Weak based on the range of values set according to patient's age and gender. Camry Digital Handgrip Dynamometer (Model EH101) which is used in our study has been validated as per a study conducted by Lupton-Smith A in 2022 [13] against the gold standard JAMAR® Dynamometer (ModelJ00105).

In a study conducted by Shah S, Nahar P, Vaidya S, Salvi S on upper limb muscle strength & endurance in COPD, the mean handgrip strength in male COPD patients was 21.8±4.7 kg and was significantly lesser than the normal males (31.2±4.3 kg,P<0.001) while in females, the mean handgrip strength in COPD patients was 19.2±3.4 kg and was significantly lesser than the normal controls (23.0±1.9 kg,P<0.001)(7).

In our study, among the total sample of 72 participants, 15.3%(n=11) exhibited normal hand grip strength, while the majority 84.7%(n=61) exhibited weak hand grip strength. Mean Hand grip strength in males is observed to be 19.7±5.57 Kg while in females, the mean hand grip strength is 11.62±2.44 kg.

Since, normal hand grip strength for an individual is a range of values and differs according to a particular gender and age group, for comparison, percentage is found to be a better tool than the mean value.

$$Hand\ grip\ strength\ percentage = \frac{measured\ hand\ grip\ strength}{lowest\ value\ of\ normal\ range} \times 100$$

Hence, an individual with 100% or more hand grip strength is considered to be normal in this study, since the lowest value of normal is taken into consideration for calculating the hand grip strength percentage. It is found that hand grip strength percentage is found to be 75.64 ±22.25% in males with COPD compared to 68.04 ±16.5% in females with COPD. Thus, it is observed that hand grip strength is significantly reduced in males and females based on the preset normal values of hand grip strength based on their corresponding age and gender(FIGURE 4).

Kovarik M, Joskova V, et al in their study on hand grip endurance test in COPD patients illustrated that the lowest strength and endurance were found in the category of combined COPD assessment corresponding to the group of patients with high risk and more symptoms (and highest GOLD stage).

The lowest strength and endurance were found in the subgroup of patients with the highest BODE score and a correlation test revealed a significant association of strength and endurance with the BODE index [14]. Puhan et al found that endurance (determined with STS test) predicted 2-year mortality almost as well as the ADO index(Age, Dyspnea, Airflow Obstruction).

Here, the Pearson correlation test was done to correlate Hand grip strength and percentage vs other predictors of morbidity and mortality like 6-minute walk distance, BODE index and GOLD stage.

It demonstrates that both hand grip strength and hand grip strength percentage show significant positive association about 6 min walk distance (r=0.72; p=0.0001 and r=0.69;p=0.0001) and significant negative correlation about BODE INDEX (r=-0.68; p=0.0001 and r=-0.75and p=0.0001), while GOLD stages which indicate the airflow limitation(FEV1) did not show any correlation with hand grip strength but showed significance with hand grip strength percentage(r=-0.37 and p=0.001). (TABLE 3 &4).

Thus it is observed that, with a reduction in hand grip strength, there is a reduction in 6-minute walk distance which concludes that hand grip strength may also be used to assess the functional status of COPD patients. It is also observed that hand grip strength reduction is more in patients with a higher BODE index which proposes that, hand grip strength correlates with the disease severity.

Conclusion

From our study, we can conclude that there is a significant reduction in hand grip strength in COPD patients and it is observed that with a reduction in hand grip strength, there is a reduction in 6-minute walk distance which suggests that hand grip strength may also be used to assess the functional status of COPD patients.

It is also observed that hand grip strength reduction is more in patients with a higher BODE index which implies that, hand grip strength correlates with the disease severity.

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Conflict of interest: None Initiated

LIST OF FIGURES:

FIGURE 1: DIGITAL HAND GRIP DYNAMOMETER

AGE	Weak	Normal	Strong
10-11	< 12.6	12.6-22.4	> 22.4
12-13	< 19.4	19.4-31.2	> 31.2
14-15	< 28.5	28.5-44.3	> 44.3
16-17	< 32.6	32.6-52.4	> 52.4
18-19	< 35.7	35.7-55.5	> 55.5
20-24	< 36.8	36.8-56.6	> 56.6
25-29	< 37.7	37.7-57.5	> 57.5
30-34	< 36.0	36.0-55.8	> 55.8
35-39	< 35.8	35.8-55.6	> 55.6
40-44	< 35.5	35.5-55.3	> 55.3
45-49	< 34.7	34.7-54.5	> 54.5
50-54	< 32.9	32.9-50.7	> 50.7
55-59	< 30.7	30.7-48.5	> 48.5
60-64	< 30.2	30.2-48.0	> 48.0
65-69	< 28.2	28.2-44.0	> 44.0
70-99	< 21.3	21.3-35.1	> 35.1

FIGURE 2: GRIP STRENGTH RATINGS FOR MALES (IN KG)

AGE	Weak	Normal	Strong
10-11	< 11.8	11.8-21.6	> 21.6
12-13	< 14.6	14.6-24.4	> 24.4
14-15	< 15.5	15.5-27.3	> 27.3
16-17	< 17.2	17.2-29.0	> 29.0
18-19	< 19.2	19.2-31.0	> 31.0
20-24	< 21.5	21.5-35.3	> 35.3
25-29	< 25.6	25.6-41.4	> 41.4
30-34	< 21.5	21.5-35.3	> 35.3
35-39	< 20.3	20.3-34.1	> 34.1
40-44	< 18.9	18.9-32.7	> 32.7
45-49	< 18.6	18.6-32.4	> 32.4
50-54	< 18.1	18.1-31.9	> 31.9
55-59	< 17.7	17.7-31.5	> 31.5
60-64	< 17.2	17.2-31.0	> 31.0
65-69	< 15.4	15.4-27.2	> 27.2
70-99	< 14.7	14.7-24.5	> 24.5

FIGURE 3: GRIP STRENGTH RATINGS FOR FEMALES (IN KG)

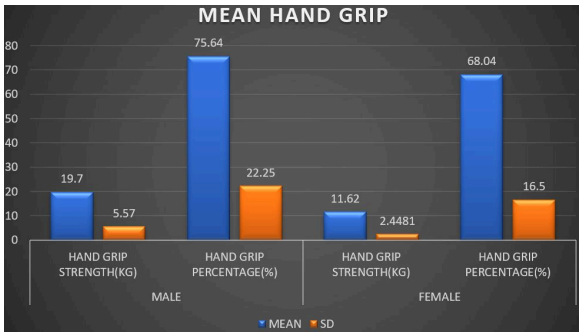

FIGURE 4: MEAN HAND GRIP STRENGTH AND PERCENTAGE AMONG COPD PATIENTS

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