“Correlation of Anthropometric Indices with Skeletal Muscle Atrophy in Patients with COPD: A One-Year Cross-Sectional Study.”

UNDERTAKING

ACCEPTANCE LETTER

LIST OF ABBREVIATIONS

6MWD	Six-Minute Walk Distance
AMPK	AMP-Activated Protein Kinase
ASM	Appendicular Skeletal Muscle Mass
ASMI	Appendicular Skeletal Muscle Mass Index
ATS	American Thoracic Society
AUC	Area Under the Curve
BCAA	Branched-Chain Amino Acids
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
BODE Index	Body Mass Index, Airflow Obstruction, Dyspnea, Exercise Capacity Index
CAT	COPD Assessment Test
CC	Calf Circumference
COPD	Chronic Obstructive Pulmonary Disease
CRP	C-Reactive Protein
CT	Computed Tomography
CVA	Cerebrovascular Accident
DALYs	Disability-Adjusted Life Years
DEXA	Dual-Energy X-ray Absorptiometry
DM	Diabetes Mellitus
ERS	European Respiratory Society
FEV_1	Forced Expiratory Volume in One Second
FFM	Fat-Free Mass
FFMI	Fat-Free Mass Index
FVC	Forced Vital Capacity
GBD	Global Burden of Disease
GOLD	Global Initiative for Chronic Obstructive Lung Disease
HRQoL	Health-Related Quality of Life
HTN	Hypertension
ICMR	Indian Council of Medical Research
ICS	Inhaled Corticosteroids

ICU	Intensive Care Unit
IHD	Ischemic Heart Disease
IGF-1	Insulin-Like Growth Factor-1
IL-6	Interleukin-6
LMICs	Low- and Middle-Income Countries
MAC	Mid-Arm Circumference
MAMA	Mid-Arm Muscle Area
MAMC	Mid-Arm Muscle Circumference
MCID	Minimum Clinically Important Difference
mMRC	Modified Medical Research Council Dyspnea Scale
MRI	Magnetic Resonance Imaging
NPCDCS	National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke
OPD	Outpatient Department
PGC-1α	Peroxisome Proliferator-Activated Receptor Gamma Coactivator 1-Alpha
PR	Pulmonary Rehabilitation
ROC	Receiver Operating Characteristic
ROS	Reactive Oxygen Species
SGRQ	St. George's Respiratory Questionnaire
SGRQ-A	St. George's Respiratory Questionnaire – Activity Domain
SGRQ-C	St. George's Respiratory Questionnaire for COPD
SGRQ-I	St. George's Respiratory Questionnaire – Impact Domain
SGRQ-S	St. George's Respiratory Questionnaire – Symptom Domain
SpO_2	Peripheral Oxygen Saturation
TB	Tuberculosis
TGF-β	Transforming Growth Factor-Beta
TNF-α	Tumor Necrosis Factor-Alpha
TSF / TSFT	Triceps Skinfold Thickness
VO_2max	Maximum Oxygen Uptake
WHO	World Health Organization

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is associated with systemic manifestations, among which skeletal muscle atrophy is a major determinant of functional limitation and poor quality of life. Identification of muscle depletion using simple, feasible methods is essential, particularly in routine clinical practice.

Objectives: [redacted]

Methods: [redacted]

Results: [redacted]

Conclusions: [redacted]

Keywords: Chronic obstructive pulmonary disease; Skeletal muscle atrophy; Anthropometric indices; Calf circumference; Appendicular skeletal muscle mass; Fat-free mass index; Sarcopenia; Body composition; Physical activity; Hypoxemia

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INTRODUCTION

INTRODUCTION

According to the World Health Organization (WHO), chronic obstructive pulmonary disease (COPD) is defined as a common, preventable, and treatable disease characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities, usually caused by significant exposure to noxious particles or gases. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- Histopathological studies demonstrate a shift in muscle fiber composition from oxidative type I fibers to glycolytic type II fibers in COPD patients [12].
- This shift in muscle fiber type results in reduced endurance capacity and increased fatigability, particularly in severe COPD [12].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] Strengthening the evidence linking anthropometric measurements to muscle atrophy in COPD enhanced clinical assessment, promote individualized patient care, and contribute to reducing the overall disease burden [17].

Global Epidemiology

Chronic obstructive pulmonary disease (COPD) is a major global public health challenge, ranking as the third leading cause of death worldwide, according to the World Health Organization (WHO, 2023). [redacted] Aging populations, environmental exposure, and delayed diagnosis continue to exacerbate the disease prevalence and socioeconomic impact globally [20].

Indian Epidemiology

India bears one of the largest COPD burdens in the world, with estimates suggesting over 55 million cases, contributing to nearly 18% of the global COPD deaths. [redacted] Despite national initiatives like the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS), underdiagnosis and inadequate access to spirometry hinder effective COPD management in India [23].

Karnataka Epidemiology

[redacted] Karnataka's diverse topography and climatic variations contribute to region-specific differences, with northern districts showing relatively higher morbidity and mortality rates.

Prevalence also of muscle atrophy in Chronic Obstructive Pulmonary Disease patients with regard to Body Mass Index

Globally, skeletal muscle atrophy and sarcopenia are common systemic manifestations of COPD, with reported prevalence ranging widely from approximately 15% to over 50%, depending on disease severity, age, and diagnostic criteria, with pooled estimates from meta-analyses indicating an overall prevalence of around 22–27% among COPD patients [24]. [redacted] This underscores the need for early identification using reliable anthropometric and body composition indicators beyond BMI, particularly in resource-limited settings [15].

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES

OBJECTIVES:

Primary Objective:

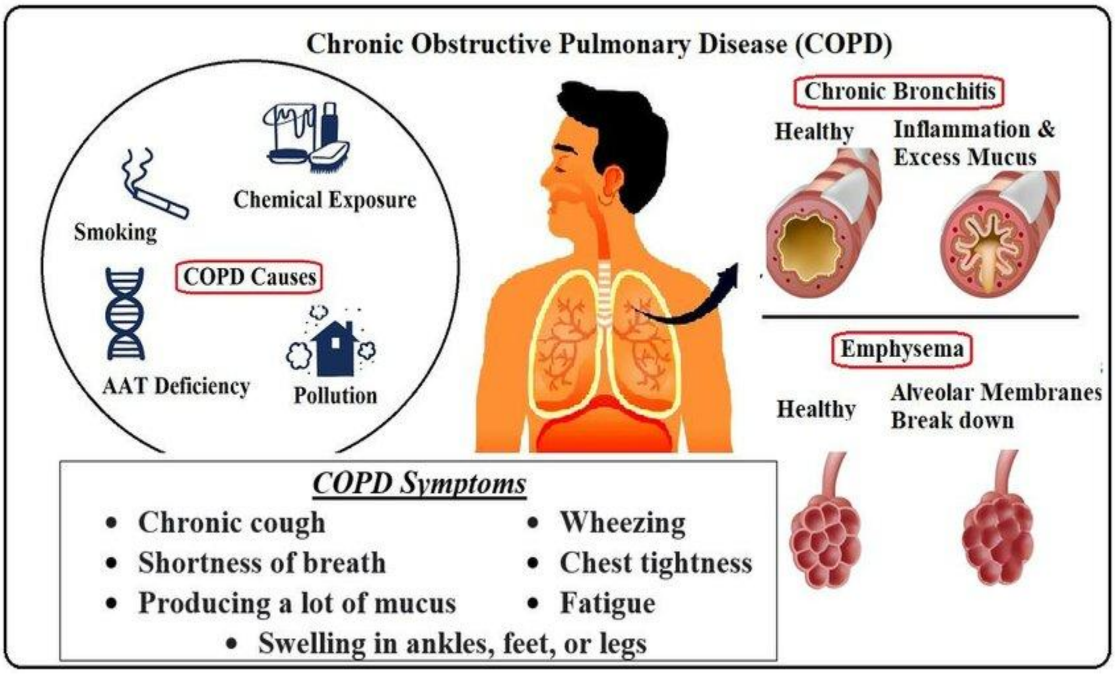
[redacted]

Secondary Objective:

[redacted]

REVIEW OF LITERATURE

REVIEW OF LITERATURE



Chronic Obstructive Pulmonary Disease (COPD)

Chronic Obstructive Pulmonary Disease (COPD), as defined by the World Health Organization (WHO), is a common, preventable, and treatable disease characterized by persistent respiratory symptoms and airflow limitation that is not fully reversible [1]. [redacted]

[redacted]

[redacted]

[redacted] The disease thus represents an integrated model of pulmonary and systemic pathology requiring a multidisciplinary approach [1].

Persistent Airflow Limitation and Chronic Inflammatory Response

The hallmark feature of COPD is persistent airflow limitation, which develops as a result of chronic inflammation and structural remodelling of the airways and lung parenchyma. [redacted]

[redacted]

Characteristic	Underlying Mechanism	Clinical Impact
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

GOLD 2024 Classification and Staging

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2024 guidelines classify COPD based on spirometric findings, symptom burden, and exacerbation risk. [redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

GOLD 2024 Component	Parameter	Clinical Relevance
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Major Clinical Symptoms: Chronic Cough, Sputum Production, and Dyspnea

COPD presents with characteristic respiratory symptoms that evolve insidiously and progressively over years. [redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted] Recognition of these core symptoms is essential for early diagnosis and monitoring disease progression [35].

Pathophysiology of COPD

Structural Airway Changes and Alveolar Destruction

Structural alterations in COPD form the pathological foundation for persistent airflow limitation. [redacted]

[redacted]

[redacted]

[redacted]

Structural Site	Pathological Change	Functional Consequence
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Mechanisms of Airflow Limitation: Small Airway Fibrosis, Mucus Hypersecretion, and Loss of Elastic Recoil

Airflow limitation in COPD arises from a combination of anatomical narrowing and mechanical dysfunction. [redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

Together, these mechanisms explain the progressive and largely irreversible airflow limitation characteristic of COPD, linking histological changes to functional decline.

Role of Chronic Inflammation, Oxidative Stress, and Protease–Antiprotease Imbalance

The central pathogenic mechanism in COPD involves persistent airway inflammation accompanied by oxidative injury and an imbalance between proteases and antiproteases. [redacted]

[redacted]

[redacted]

These interconnected mechanisms explain why COPD persists even after smoking cessation, as the self-sustaining inflammatory and proteolytic environment continues to damage lung parenchyma.

Systemic Spillover of Inflammatory Mediators from Lungs to Circulation

COPD is increasingly recognized as a systemic inflammatory disease rather than an organ-limited disorder. [redacted]

[redacted] Oxidative stress within muscle tissue further aggravates these effects, linking pulmonary pathology to peripheral dysfunction [46].

Main pathways involved in systemic inflammation:

- Cytokine diffusion from alveolar-capillary interface to bloodstream.
- Activation of acute-phase response with elevated CRP and fibrinogen.
- [redacted]

[redacted]

Systemic Manifestations of COPD

COPD as a Multisystem Disorder

Chronic Obstructive Pulmonary Disease (COPD) has traditionally been regarded as a disease of the lungs characterized by airflow limitation and structural airway damage. [redacted]

[redacted]

- [redacted]

[redacted] This integrated perspective supports early detection and targeted interventions aimed at improving long-term outcomes [35].

Common Systemic Effects: Weight Loss, Cachexia, Cardiovascular Dysfunction, and Metabolic Derangements

The systemic manifestations of COPD arise from chronic inflammation and persistent hypoxia affecting multiple organ systems. [redacted]

[redacted]

Other systemic effects include skeletal muscle weakness, osteoporosis, and anaemia all of which add to morbidity and limit functional capacity.

Important systemic consequences observed in COPD:

- Weight loss and muscle wasting due to catabolic dominance.
- [redacted]

[redacted]

Systemic Manifestation	Underlying Mechanism	Clinical Consequence
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Risk Factors of COPD

Chronic Obstructive Pulmonary Disease is a preventable and progressive respiratory disorder caused by long-term exposure to noxious particles and gases. [redacted]

Tobacco Smoking

[redacted]

[redacted] Although smoking cessation slows disease progression, the structural damage caused by long-term smoking is largely irreversible [52].

Biogas and Biomass Fuel Exposure

Exposure to biogas and biomass fuel smoke is a major risk factor for COPD, especially in rural and low-income populations. [redacted]

[redacted]

[redacted] Biomass-related COPD often shows predominant airway disease rather than emphysema and is frequently underdiagnosed due to limited access to spirometry in rural settings [55].

Occupational Exposure to Dusts and Chemicals

[redacted] The risk increases with duration of exposure and inadequate use of protective equipment [43].

Outdoor Air Pollution

[redacted] Urban populations and individuals living near highways or industrial areas are particularly vulnerable [56].

Childhood Respiratory Infections

[redacted] Poor access to healthcare and delayed treatment further increases this risk [57].

Genetic and Host Factors

Genetic susceptibility plays a contributory role in COPD development. Alpha-1 antitrypsin deficiency is a well-recognized genetic cause leading to early-onset emphysema, especially in smokers. [redacted]

Asthma and Airway Hyper-responsiveness

Long-standing or poorly controlled asthma can lead to airway remodeling and fixed airflow obstruction, increasing the risk of developing COPD. [redacted]

Socioeconomic and Environmental Factors

[redacted]

Skeletal Muscle Dysfunction in COPD

Skeletal muscle dysfunction is a prominent extrapulmonary manifestation of Chronic Obstructive Pulmonary Disease (COPD). [redacted]

[redacted]

[redacted]

Muscle wasting thus represents a critical systemic marker of disease severity and overall health deterioration, significantly influencing prognosis and quality of life in COPD patients.

Distribution of Muscle Involvement (Predominantly Lower Limb Muscles)

The distribution of skeletal muscle involvement in COPD is not uniform. [redacted]

[redacted] This pattern contributes to exercise limitation, as walking and climbing stairs become increasingly difficult for affected individuals [64].

Main observations regarding distribution of muscle involvement:

- Marked atrophy and weakness in quadriceps, gluteal, and calf muscles.
- [redacted]

This preferential lower limb involvement explains the progressive decline in exercise tolerance and underscores the importance of targeted rehabilitation focusing on peripheral muscle conditioning.

Pathophysiological Mechanisms of Muscle Wasting

Muscle atrophy in COPD results from a combination of molecular, metabolic, and behavioural mechanisms that promote catabolism and inhibit muscle regeneration. [redacted]

Hypoxia-Induced Apoptosis and Mitochondrial Dysfunction

Chronic hypoxemia reduces oxygen delivery to skeletal muscles, impairing oxidative phosphorylation and ATP production. [redacted]

[redacted] The cumulative loss of muscle fibers reduces contractile strength and endurance capacity [65].

Cytokine-Mediated Protein Degradation (TNF-α, IL-6)

Inflammatory cytokines such as TNF-α and IL-6 activate proteolytic pathways including the ubiquitin–proteasome system, accelerating muscle protein breakdown. [redacted]

Physical Inactivity and Disuse Atrophy

Reduced physical activity due to dyspnea and fatigue leads to disuse atrophy, particularly affecting type I oxidative fibers. [redacted]

Nutritional Deficiency and Altered Anabolic Hormones (Testosterone, IGF-1)

Poor appetite, malabsorption, and increased resting energy expenditure cause nutritional deficiencies that limit substrate availability for muscle repair. [redacted]

Mechanisms contributing to muscle wasting:

- Persistent hypoxia causing oxidative damage and apoptosis.
- [redacted]

[redacted]

Mechanism	Primary Process	Effect on Muscle Tissue
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Consequences: Reduced Exercise Capacity, Increased Dyspnea, Impaired Daily Activity

The clinical consequences of skeletal muscle atrophy in COPD are profound, extending beyond physical weakness to functional disability and diminished survival. [redacted]

[redacted]

- [redacted]

[redacted] Its recognition and management are vital components of comprehensive respiratory care, aiming to improve quality of life and preserve independence in affected individuals [63].

Cellular and Molecular Mechanisms of Skeletal Muscle Atrophy

Role of Oxidative Stress and Reactive Oxygen Species

Oxidative stress plays a central role in the pathogenesis of skeletal muscle dysfunction in Chronic Obstructive Pulmonary Disease (COPD). [redacted]

[redacted] This sustained oxidative insult contributes to muscle fatigue, reduced endurance, and increased susceptibility to injury during exertion [50].

Major consequences of oxidative stress in COPD-associated muscle dysfunction include:

- Structural injury to myofibrils and contractile proteins.
- [redacted]

Therefore, oxidative stress represents a key pathogenic mechanism linking chronic inflammation, mitochondrial dysfunction, and muscle wasting in COPD, forming the biochemical foundation for sarcopenia and cachexia seen in advanced disease [68].

Muscle Fiber Transition from Oxidative (Type I) to Glycolytic (Type II) Phenotype

One of the most characteristic findings in COPD-related muscle dysfunction is the shift in muscle fiber composition from oxidative (type I) fibers to glycolytic (type II) fibers. [redacted]

[redacted]

[redacted]

This fiber remodelling reflects adaptation to chronic inactivity and hypoxia but ultimately worsens functional performance and exercise limitation in COPD patients.

Decreased Oxidative Enzyme Activity and Mitochondrial Density

The metabolic hallmark of skeletal muscle dysfunction in COPD is reduced oxidative capacity resulting from decreased oxidative enzyme activity and mitochondrial density. [redacted]

[redacted] The resulting energy deficit contributes to early fatigue and diminished endurance during physical exertion [74].

Major metabolic consequences include:

- Decreased efficiency of oxidative phosphorylation and ATP yield.

[redacted]

This reduction in oxidative capacity is a central mechanism linking biochemical, structural, and functional decline of skeletal muscles in COPD, explaining the profound exercise intolerance observed even in patients with moderate disease severity.

Functional Consequences of Muscle Atrophy in COPD

Relationship Between Muscle Loss and Decreased Exercise Tolerance

Muscle loss in Chronic Obstructive Pulmonary Disease (COPD) has a direct and profound impact on exercise tolerance. [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

Thus, muscle loss creates a vicious cycle where physical inactivity worsens muscle atrophy, which in turn further restricts exercise capacity, contributing significantly to disability and dependence in COPD patients [75].

Contribution to Ventilatory Inefficiency and Early Fatigability

Ventilatory inefficiency is a hallmark of advanced COPD and is exacerbated by skeletal muscle dysfunction. [redacted]

[redacted] The combined

effects of muscle atrophy, decreased strength, and altered metabolic profile amplify ventilatory inefficiency and fatigue [77].

Main contributors to ventilatory inefficiency and fatigue:

- Reduced oxidative capacity leading to higher oxygen cost of movement.

[redacted]

This interplay between muscular and ventilatory systems highlights why pulmonary rehabilitation that targets both respiratory and limb muscle conditioning is vital for improving functional outcomes [77].

Association with Reduced 6-Minute Walk Distance and Quality of Life

The 6-minute walk distance (6MWD) is a simple and reliable indicator of functional status in COPD, reflecting the integrated performance of respiratory, cardiovascular, and musculoskeletal systems. [redacted]

[redacted] These limitations are often reflected in higher scores on symptom assessment tools such as the Modified Medical Research Council (mMRC) Dyspnea Scale and the COPD Assessment Test (CAT) [79].

Core associations between muscle loss and functional impairment:

- Decreased walking distance due to loss of power and endurance.

[redacted]

Parameter	Effect of Muscle Loss	Clinical Implication
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Muscle preservation and strengthening through nutritional and rehabilitative interventions are therefore critical to maintain mobility and improve life quality in COPD.

Prognostic Implications: Mortality and Frequency of Exacerbations

Skeletal muscle wasting in COPD is not only a functional impairment but also a strong prognostic marker of disease severity and mortality. [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted] Early interventions aimed at reversing or stabilizing muscle loss can significantly improve survival, reduce exacerbation rates, and enhance overall patient outcomes in COPD [80].

Assessment of Skeletal Muscle Mass and Function in COPD

Available Assessment Methods

Assessment of skeletal muscle mass and function in Chronic Obstructive Pulmonary Disease (COPD) is an essential component of evaluating disease severity, exercise capacity, and prognosis. [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

A comprehensive evaluation often combines a structural assessment [redacted]

Direct Techniques: DEXA, CT, MRI, and Bioelectrical Impedance

- [redacted] **Dual-Energy X-ray Absorptiometry (DEXA):** [redacted]
- [redacted] **Computed Tomography (CT):** [redacted]
- [redacted] **Magnetic Resonance Imaging (MRI):** [redacted]

[redacted]

- [redacted] **Bioelectrical Impedance Analysis (BIA):** [redacted]

Direct measurement techniques:

- DEXA: precise, reproducible, radiation exposure minimal.

[redacted]

Method	Advantages	Limitations
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Limitations of Advanced Imaging in Clinical Settings

Although DEXA, CT, and MRI provide excellent accuracy, their routine use in clinical practice is often restricted by several practical barriers. [redacted]

[redacted]

[redacted]

- High financial and infrastructural requirements.
- Limited accessibility outside tertiary centers.
- [redacted]

[redacted]

Need for Simple, Reliable, and Non-Invasive Alternatives

Given the constraints of advanced imaging, there is a strong clinical need for simple, reproducible, and non-invasive alternatives that can be implemented in outpatient and bedside settings. [redacted]

[redacted] In addition, combining anthropometric assessment with functional tests such as handgrip strength or 6-minute walk distance enhances diagnostic accuracy and prognostic utility [6].

Important advantages of simple anthropometric approaches:

- Non-invasive, low-cost, and suitable for repeated evaluations.
- [redacted]

Therefore, in the context of COPD, anthropometric indices serve as a clinically viable alternative to complex imaging methods, bridging the gap between precision assessment and real-world applicability, and are especially beneficial in low-resource healthcare environments [6].

Role of Anthropometric Indices in COPD Evaluation

Importance of Anthropometry in Assessing Nutritional and Muscular Status

Anthropometry serves as one of the most practical and clinically relevant tools for assessing nutritional status and skeletal muscle mass in patients with Chronic Obstructive Pulmonary Disease (COPD). [redacted]

[redacted]

Anthropometry also helps in risk stratification patients with lower values in specific indices are more likely to experience poor exercise tolerance, increased hospitalization, and higher mortality [17].

Salient advantages of anthropometric assessment include:

- Simple, reproducible, and inexpensive bedside technique.

[redacted]

Through these advantages, anthropometry bridges the gap between complex imaging and practical bedside assessment, forming an integral component of COPD management and follow-up.

Common Indices Used

[redacted]**Body Mass Index (BMI)**: [redacted]

- **Mid-Arm Circumference (MAC):** [redacted]

[redacted]

[redacted] **Mid-Arm Muscle Circumference (MAMC):** [redacted]

[redacted] **MAMC = MAC − (π × Triceps Skinfold Thickness)**: [redacted]

- **Calf Circumference (CC):** [redacted]

[redacted] **Fat-Free Mass Index (FFMI):** [redacted]

[redacted] **Appendicular Skeletal Muscle Mass Index (ASMI):** [redacted]

Index	Measurement Basis	Interpretation	Cutoff for Muscle Depletion
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Clinical Interpretation and Cutoff Values for Muscle Atrophy

Clinical interpretation of anthropometric parameters in COPD involves comparing measured values against established reference standards. [redacted] Cutoff values below normal thresholds indicate significant muscle depletion or sarcopenia [17].

In COPD, these reduced measurements are associated with:

[redacted]

Important clinical cutoffs for identifying muscle atrophy:

[redacted]

Using these cutoffs enables early recognition of muscle loss, guiding nutritional supplementation and exercise interventions tailored to disease severity.

Comparative Value of Each Index in Reflecting Muscle Loss and Function

Each anthropometric index provides distinct clinical information, and their comparative evaluation enhances diagnostic precision. [redacted]

[redacted] FFMI and ASMI remain the most comprehensive indicators, integrating body composition with functional status [97].

Relative clinical usefulness of indices:

- BMI: Global nutritional screening; limited for detecting isolated muscle loss.

[redacted]

[redacted]

Anthropometric assessment provides an accessible, reproducible, and clinically meaningful approach for evaluating muscle mass and nutritional status in COPD, forming a cornerstone for disease monitoring and holistic management [17].

Anthropometric Indicators and Disease Severity in COPD

Relationship Between Anthropometric Indices and Spirometric Parameters (FEV_1, FVC, FEV_1/FVC Ratio)

Anthropometric indices provide valuable insight into the systemic impact of Chronic Obstructive Pulmonary Disease (COPD) and correlate strongly with spirometric parameters such as Forced Expiratory Volume in one second (FEV_1), Forced Vital Capacity (FVC), and the FEV_1/FVC ratio. [redacted]

[redacted] This relationship demonstrates the systemic nature of COPD, where pulmonary and peripheral deterioration occur concurrently [99].

Mechanisms linking anthropometry and spirometry:

- Muscle atrophy reduces ventilatory muscle strength, limiting expiratory flow.
- [redacted]

[redacted]

Parameter	Physiological Correlation	Clinical Implication
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Association with GOLD Staging and BODE Index

Anthropometric indices show a strong association with Global Initiative for Chronic Obstructive Lung Disease (GOLD) staging, which classifies COPD severity based on airflow limitation, symptoms, and exacerbation risk. [redacted]

[redacted] Patients with reduced anthropometric values consistently exhibit poorer performance on functional and spirometric measures [101].

Correlative trends:

- Decreasing FFMI corresponds with worsening GOLD stage (III–IV).
- [redacted]

[redacted]

These associations confirm that anthropometric parameters serve as important systemic markers within COPD staging, complementing spirometric classification by integrating nutritional and muscular dimensions [100,101].

Predictive Value of Reduced FFMI or CC in Severe COPD

Reduced Fat-Free Mass Index (FFMI) and Calf Circumference (CC) are powerful predictors of morbidity and mortality in severe COPD. [redacted]

[redacted] Both parameters correlate strongly with reduced ventilatory efficiency and higher oxygen demand during exertion, highlighting the link between peripheral muscle status and respiratory performance [103].

Predictive implications of reduced FFMI or CC:

- Early identification of sarcopenia and physical frailty.
- [redacted]

Therefore, regular monitoring of FFMI and CC enables timely recognition of high-risk patients and facilitates early intervention through nutritional supplementation, exercise therapy, and pharmacological optimization.

Physiological Interdependence between Respiratory and Skeletal Muscle Function

Role of Respiratory Muscle Weakness in COPD Progression

Respiratory muscle weakness is a critical yet often underappreciated component of Chronic Obstructive Pulmonary Disease (COPD) pathophysiology. [redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted] As a result, patients experience earlier onset of respiratory failure and greater difficulty recovering from exacerbations, underscoring the vital role of respiratory muscle integrity in COPD prognosis [106].

Shared Mechanisms of Limb and Respiratory Muscle Dysfunction

The dysfunction observed in limb and respiratory muscles in COPD shares common pathophysiological mechanisms, indicating that skeletal muscle impairment is a systemic phenomenon rather than a localized process. [redacted]

[redacted] In addition, mitochondrial dysfunction and impaired calcium homeostasis reduce energy efficiency and endurance capacity [107].

Similar adaptive changes are observed in both muscle types:

- Shift from oxidative (type I) to glycolytic (type II) fibers, reducing fatigue resistance.
- [redacted]
- [redacted]
- [redacted]

[redacted] These parallel yet distinct stressors result in a global reduction of muscle performance, contributing to functional decline and reduced quality of life [108].

Impact on Dyspnea, Exercise Intolerance, and Ventilatory Mechanics

Respiratory muscle weakness plays a direct role in the hallmark symptoms of COPD dyspnea and exercise intolerance through its adverse effects on ventilatory mechanics. [redacted]

[redacted] This not only restricts physical activity but also accelerates deconditioning of limb muscles, compounding overall exercise intolerance [109].

Physiological consequences of respiratory muscle weakness include:

- Increased dyspnea: Due to reduced inspiratory capacity and elevated work of breathing.
- [redacted]

Pathophysiological Factor	Mechanistic Outcome	Clinical Manifestation
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted] Strengthening respiratory and limb muscles through pulmonary rehabilitation, nutritional optimization, and inspiratory muscle training is therefore essential to break the cycle of breathlessness and inactivity, improving both functional capacity and prognosis [110].

Clinical Consequences of Skeletal Muscle Atrophy

Reduced Exercise Tolerance and Physical Inactivity

Reduced exercise tolerance is one of the most significant systemic consequences of Chronic Obstructive Pulmonary Disease (COPD). [redacted]

[redacted] Over time, this reduced physical activity contributes to worsening disability and decreased quality of life [111].

Major contributors to inactivity in COPD:

- Loss of muscle mass and mitochondrial function causing early fatigue.
- [redacted]

Therefore, reduced exercise tolerance and inactivity are both cause and consequence of muscle dysfunction in COPD, accelerating overall disease progression and physical dependence [111].

Worsening Dyspnea and Ventilatory Inefficiency

Dyspnea, or breathlessness, is the cardinal symptom of COPD and is closely linked to ventilatory inefficiency resulting from both pulmonary and muscular dysfunction. [redacted]

[redacted] This ventilatory

inefficiency not only aggravates dyspnea but also reduces oxygen uptake and increases carbon dioxide retention [113].

Pathophysiological factors contributing to worsening dyspnea include:

- Respiratory muscle weakness and reduced inspiratory capacity.

[redacted]

This physiological burden perpetuates avoidance of activity, further reducing exercise capacity and enhancing the perception of breathlessness, ultimately worsening functional limitation in COPD [114].

Poor Response to Pulmonary Rehabilitation and Increased Healthcare Utilization

Pulmonary rehabilitation is a cornerstone in the management of COPD; however, its effectiveness is significantly compromised in patients with severe muscle wasting. [redacted]

[redacted]

[redacted]

Thus, addressing nutritional and muscular deficits before and during rehabilitation is essential to enhance responsiveness and reduce overall healthcare burden in COPD management.

St. George's Respiratory Questionnaire (SGRQ) & SGRQ-C

St. George's Respiratory Questionnaire (SGRQ)

The St. [redacted]

[redacted]

[redacted] A change of 4 units or more in the total score is considered the minimum clinically important difference (MCID), indicating a meaningful change in a patient's health status [120].

Clinical Applications of SGRQ

The SGRQ is used to quantify baseline disease severity, compare health status between patient groups, and evaluate the effectiveness of pharmacological and non-pharmacological interventions such as bronchodilators, inhaled corticosteroids, pulmonary rehabilitation, smoking cessation programs, and long-term oxygen therapy. [redacted]

Limitations of the Original SGRQ

Despite its strengths, the original SGRQ has certain limitations. [redacted] These limitations led to the development of a modified version specifically tailored for COPD [122].

St. George's Respiratory Questionnaire for COPD (SGRQ-C)

The SGRQ-C is a COPD-specific, shortened version of the original SGRQ, developed to improve feasibility while maintaining the psychometric properties of the parent questionnaire. [redacted]

[redacted]

[redacted] The minimum clinically important difference of 4 units also applies to the SGRQ-C, allowing direct comparison with studies using the original questionnaire [124].

Advantages and Use of SGRQ-C

The SGRQ-C offers several advantages in COPD research and clinical practice. [redacted]

[redacted] It is now commonly used as a primary or secondary endpoint in clinical trials evaluating new therapies for COPD and in observational studies assessing disease burden and treatment response [126].

Higher Morbidity and Mortality in Patients with Low Muscle Mass

Low skeletal muscle mass is a strong and independent predictor of morbidity and mortality in COPD. [redacted]

[redacted]

[redacted]

Clinical Parameter	Effect of Low Muscle Mass	Outcome
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted] Early detection through anthropometric and functional assessments, coupled with targeted nutritional and exercise interventions, remains crucial for improving prognosis and quality of life in COPD patients [63].

Rehabilitation and Reversibility of Muscle Dysfunction

Benefits of Pulmonary Rehabilitation on Muscle Mass and Endurance

Pulmonary rehabilitation (PR) is one of the most effective non-pharmacological interventions for patients with Chronic Obstructive Pulmonary Disease (COPD). [redacted]

[redacted]

Major benefits of pulmonary rehabilitation include:

- Increased muscle strength and lean body mass.

[redacted]

In addition, rehabilitation has been shown to decrease hospitalization frequency, improve emotional well-being, and slow the overall decline in physical performance, making it a cornerstone of COPD management [115].

Mechanisms of Muscle Remodelling and Metabolic Adaptation

Muscle remodelling during pulmonary rehabilitation occurs through a combination of structural, metabolic, and enzymatic adaptations. [redacted]

[redacted]

[redacted]

Through these remodelling processes, skeletal muscles regain endurance capacity and functional efficiency, translating into improved exercise performance and daily activity tolerance.

Role of Resistance Training and Aerobic Conditioning

Both resistance training and aerobic conditioning form the core of pulmonary rehabilitation programs, each targeting different aspects of muscle dysfunction [132,133].

[redacted]

[redacted]

[redacted]

Regular implementation of both modalities leads to measurable improvement in 6-minute walk distance (6MWD), VO_2max, and muscle power, reflecting better integration of muscular and respiratory function [136].

Effect of Nutritional Supplementation and Anti-inflammatory Strategies

Nutritional and anti-inflammatory interventions complement pulmonary rehabilitation by addressing the underlying metabolic and inflammatory disturbances contributing to muscle wasting. [redacted]

[redacted]

[redacted] Lifestyle measures such as smoking cessation and antioxidant-rich diets further reduce oxidative stress and promote muscle recovery [140].

Essential benefits of nutritional and anti-inflammatory support:

- Enhanced muscle protein synthesis and recovery.
- [redacted]
- [redacted]
- [redacted]

Intervention Type	Mechanism of Action	Clinical Outcome
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted] These integrated interventions not only restore muscle strength and endurance but also significantly improve functional independence, reduce exacerbation risk, and enhance survival and quality of life [141].

Importance of Early Detection of Muscle Atrophy in COPD

Relevance of Identifying Subclinical Muscle Loss

[redacted]

[redacted]

[redacted]

Thus, recognizing subclinical muscle loss shifts COPD management from reactive to preventive care, enabling clinicians to intervene before systemic deterioration becomes irreversible.

Screening Approaches Using Anthropometric Indices

Anthropometric screening provides a practical, inexpensive, and non-invasive means to detect subclinical muscle loss in COPD. [redacted]

[redacted]

[redacted] Similarly, a CC <31 cm is a sensitive bedside marker of sarcopenia [143].

Effective anthropometric screening strategy:

- Measure BMI, MAMC, and CC at baseline and follow-up.

[redacted]

[redacted]

Anthropometric Parameter	Screening Threshold	Clinical Implication
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Integration of Anthropometric Evaluation into Routine COPD Management

Integrating anthropometric assessment into routine COPD management offers a holistic approach that extends beyond lung function testing to address systemic health. [redacted]

[redacted] These parameters are particularly valuable in primary and secondary care settings, where access to advanced imaging is limited [145].

Benefits of integrating anthropometry into routine care:

- Facilitates early diagnosis of sarcopenia and cachexia.
- [redacted]

[redacted]It bridges the gap between pulmonary assessment and systemic health monitoring, ensuring that muscle preservation becomes a central goal in the multidisciplinary care of COPD patients [17].

Conceptual Relationship between Anthropometric Indices and Muscle Atrophy

Anthropometry as a Surrogate Marker of Muscle Wasting

In patients with Chronic Obstructive Pulmonary Disease (COPD), anthropometry serves as an accessible and reliable surrogate marker for skeletal muscle wasting, offering an indirect yet accurate assessment of body composition. [redacted]

[redacted] These parameters not only help in detecting early sarcopenia but also predict poor exercise capacity, frequent exacerbations, and increased mortality [67].

Clinical advantages of anthropometric assessment:

- Provides a reproducible, non-invasive measure of muscle health.

[redacted] Its inclusion in regular patient evaluation ensures early recognition of muscle depletion, guiding timely nutritional and rehabilitative interventions [17].

Pathophysiological Model Linking Airflow Limitation to Muscle Dysfunction

The pathophysiological link between airflow limitation and muscle dysfunction in COPD reflects a complex interplay between pulmonary, systemic, and muscular factors. [redacted]

[redacted]

The sequential model can be summarized as follows:

1. Airflow limitation → Chronic hypoxia and systemic inflammation.

[redacted]

Understanding this pathophysiological continuum underscores the importance of addressing not only pulmonary inflammation but also systemic metabolic and muscular components of COPD to achieve comprehensive management and improved patient outcomes.

Research Studies

[redacted] **(2025)** explored sarcopenia as a frequent but under-recognized comorbidity in COPD. [redacted] Recognizing sarcopenia as a treatable trait could improve COPD management by integrating exercise and nutritional therapy into standard care, potentially slowing disease progression and improving survival outcomes among affected patients [15].

[redacted] **(2025)** described sarcopenia as a clinically actionable trait in COPD management. [redacted] It called for clinical trials evaluating combined nutritional and exercise-based interventions to reverse sarcopenia and improve health-related quality of life in COPD patients [68].

[redacted] **(2025)** established standardized recommendations for nutritional evaluation and therapy in COPD. [redacted] The authors concluded that early identification and management of nutritional abnormalities reduce disease burden and improve survival, making body composition monitoring a critical component of comprehensive COPD management and rehabilitation programs [145].

[redacted] **(2025)** assessed the accuracy of anthropometric indicators for evaluating muscle mass in older adults, including those with COPD. [redacted] The authors concluded that anthropometric measures are cost-effective and practical alternatives to detect sarcopenia, facilitating early nutritional and rehabilitative interventions aimed at improving functional capacity and prognosis in chronic respiratory disease populations, particularly among elderly individuals vulnerable to muscle loss [6].

[redacted] **(2023)** investigated the influence of body composition and sarcopenia on mortality in COPD. [redacted] Preventing sarcopenia through exercise and nutritional therapy may significantly reduce hospital admissions and improve overall survival, highlighting the importance of muscle preservation in comprehensive COPD management [127].

[redacted] **(2022)** conducted a large cross-sectional investigation in stable Chinese COPD patients to evaluate the clinical significance of simple anthropometric indices as markers of skeletal-muscle atrophy. [redacted] Incorporating these measures into outpatient practice could enable early detection of sarcopenia, timely nutritional and rehabilitative intervention, and improved prognostic assessment, especially where advanced imaging or body-composition technology is unavailable [17].

[redacted] **(2022)** computed-tomography scans to quantify skeletal and bone parameters in COPD, thereby repurposing existing imaging for systemic assessment. [redacted] The study concluded that muscle and bone quantification on CT can improve prognostic modelling, identify high-risk cachectic patients, and help tailor personalized rehabilitation and nutritional strategies to enhance survival and quality of life in COPD populations [83].

[redacted] **(2022)** presented an extensive narrative review summarizing current knowledge of COPD-associated cachexia. [redacted] The review concluded that individualized, multidisciplinary treatment targeting both metabolic and mechanical aspects of cachexia can substantially improve outcomes, making systematic evaluation of body composition a cornerstone of modern COPD care [48].

[redacted] **(2018)** investigated the relationship between anthropometric indices and COPD severity among Iranian male patients in a hospital-based cross-sectional study. [redacted] They recommended routine nutritional screening using such indices for early identification of at-risk patients, initiation of dietary counselling, and incorporation of nutritional rehabilitation into standard COPD management, particularly valuable in low-resource health-care environments where body-composition analysis is impractical [146].

[redacted] **(2018)** validated a multifrequency bioelectrical-impedance-analysis (BIA) system for assessing body composition in COPD patients and compared it with dual-energy X-ray absorptiometry (DEXA). [redacted]

[redacted] Because of its portability and non-invasive nature, BIA can facilitate large-scale community screening, longitudinal follow-up, and assessment of the efficacy of nutritional or rehabilitative interventions aimed at preserving lean body mass and functional capacity in COPD [87].

[redacted] **(2018)** produced a detailed narrative review exploring the interplay between nutritional status and muscle dysfunction across chronic respiratory diseases, focusing primarily on COPD. [redacted] Strengthening both respiratory and peripheral muscles through combined nutritional and rehabilitative approaches remains a pivotal goal in comprehensive COPD care [116].

[redacted] **(2017)** evaluate nutritional status among COPD patients using BMI, mid-arm circumference, and triceps skinfold thickness as principal anthropometric indicators. [redacted] They concluded that structured nutritional-support and monitoring programs should be integral to COPD management to prevent cachexia, improve quality of life, and enhance outcomes, particularly in developing-country settings with high disease burden [16].

[redacted] **(2016)** explored how different anthropometric indicators relate to pulmonary-function parameters in COPD. [redacted] They recommended individualized management strategies emphasizing muscle-mass preservation through exercise and dietary optimization while addressing central fat reduction to improve pulmonary efficiency [147].

[redacted] **(2016)** compared the predictive power of limb-circumference measurements with BMI for long-term mortality in COPD. [redacted] Early nutritional counselling and resistance-exercise rehabilitation targeting limb-muscle preservation may therefore substantially improve longevity and functional outcomes in COPD [7].

[redacted] **(2015)** investigated dietary patterns in moderate-to-severe COPD and their relationship with fat-free-mass index. [redacted]

[redacted] Optimizing dietary intake not only maintains muscle mass but also enhances immune function and overall disease control, thereby reducing exacerbations and improving quality of life [10].

[redacted] **(2014)** reviewed the spectrum of musculoskeletal disorders accompanying COPD, with special attention to skeletal-muscle dysfunction and osteoporosis. [redacted] They concluded that targeted rehabilitation and nutritional therapy addressing both skeletal-muscle and bone pathology can meaningfully improve function, reduce falls and fractures, and enhance overall survival in patients with chronic obstructive pulmonary disease [148].

[redacted] **(2014)** examined alterations in body composition among COPD patients using bioelectrical impedance analysis. [redacted] They concluded that regular body-composition evaluation should be incorporated into COPD management protocols to detect early muscle loss, guide dietary and exercise interventions, and prevent progression to debilitating cachexia, thereby improving quality of life and clinical outcomes [143].

[redacted] **(2012)** conducted an interventional study evaluating the effect of resistance training on lower-limb muscle mass in COPD using ultrasound imaging. [redacted] They concluded that combining imaging-based muscle assessment with individualized exercise regimens effectively mitigates sarcopenia, reduces fatigue, and enhances independence, underscoring the reversible nature of COPD-related muscular dysfunction when adequately addressed [89].

[redacted] **(2010)** explored relationships between nutritional status, fat-free-mass index, inspiratory-muscle strength, and exercise capacity in severe COPD. [redacted] They concluded that maintaining adequate fat-free mass through high-protein diets and exercise training can improve respiratory-muscle strength, exercise endurance, and overall prognosis, highlighting nutrition as a cornerstone of comprehensive COPD care [149].

[redacted] **(2007)** compared BMI and fat-free-mass index (FFMI) as indicators of disease severity in COPD. [redacted] Recognizing and addressing low FFMI through targeted nutrition and resistance training could mitigate functional decline and improve long-term survival [102].

[redacted] **(2005)** performed a prospective five-year follow-up study establishing mid-arm-muscle area (MAMA) as a superior predictor of mortality compared with BMI in COPD. [redacted] The authors concluded that anthropometric evaluation of muscle reserves should replace BMI in prognostic assessment, and that early identification of muscular depletion should prompt nutritional and rehabilitative interventions aimed at preserving lean mass and extending survival [8].

[redacted] **(2005)** investigated relationships between detailed body composition and mortality in COPD using dual-energy X-ray absorptiometry. [redacted] Their work shifted clinical focus from BMI to body-composition analysis in COPD management, influencing subsequent guideline recommendations [80].

Need for the Present Study

Chronic Obstructive Pulmonary Disease (COPD) is no longer considered a disease confined solely to the lungs but a systemic disorder with significant extrapulmonary manifestations. [redacted]

[redacted]

[redacted]

[redacted]

- To evaluate muscle mass depletion and nutritional status using simple anthropometric indices in stable COPD patients.
- To explore the relationship between anthropometric parameters and pulmonary function, reflecting the systemic impact of COPD.
- [redacted]
- [redacted]
- [redacted]

[redacted] Such insights not only enhanced clinical monitoring but also support the development of integrated rehabilitation and nutritional interventions, ultimately improving patient outcomes and quality of life.

MATERIALS AND METHODS

MATERIALS AND METHODS

Source of Data: [redacted]

Study Design: [redacted]

Study Period: [redacted]

Sample Size:

[redacted]

Sampling Technique: [redacted]

Inclusion Criteria:

[redacted]

[redacted]

Exclusion Criteria:

[redacted]

[redacted]

[redacted]

Study Protocol: [redacted]

[redacted]

Data Collection Procedure: [redacted]

The following procedure was adopted for data collection:

1. Identification and Recruitment of Study Participants: [redacted]

[redacted]

2. Recording of Demographic and Clinical Data: [redacted]

Smoking index was calculated as:

[redacted]

[redacted]

3. Anthropometric Measurements: [redacted]

Parameters included:

[redacted]

[redacted]

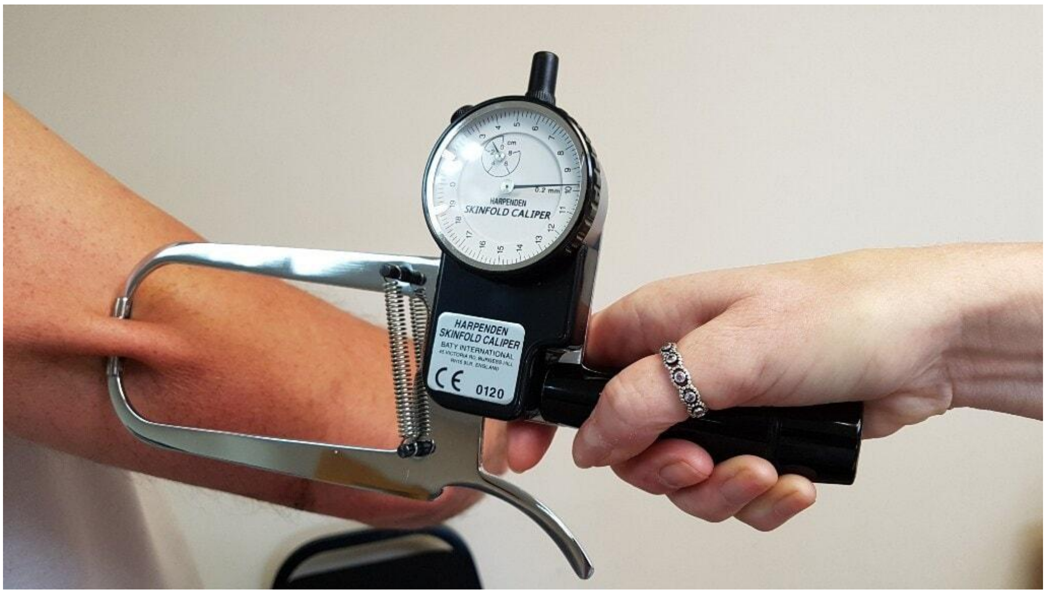


Figure Harpenden Skinfold Caliper

[redacted]

[redacted]

4. Spirometric Evaluation: [redacted]

The following parameters were recorded:

[redacted]

5. Correlation of Anthropometric and Spirometric Data: [redacted]

6. Quality Control and Data Verification: [redacted]

7. Data Documentation and Confidentiality: [redacted]

Data Processing and Analysis/Statistical Analysis:

[redacted]

RESULTS

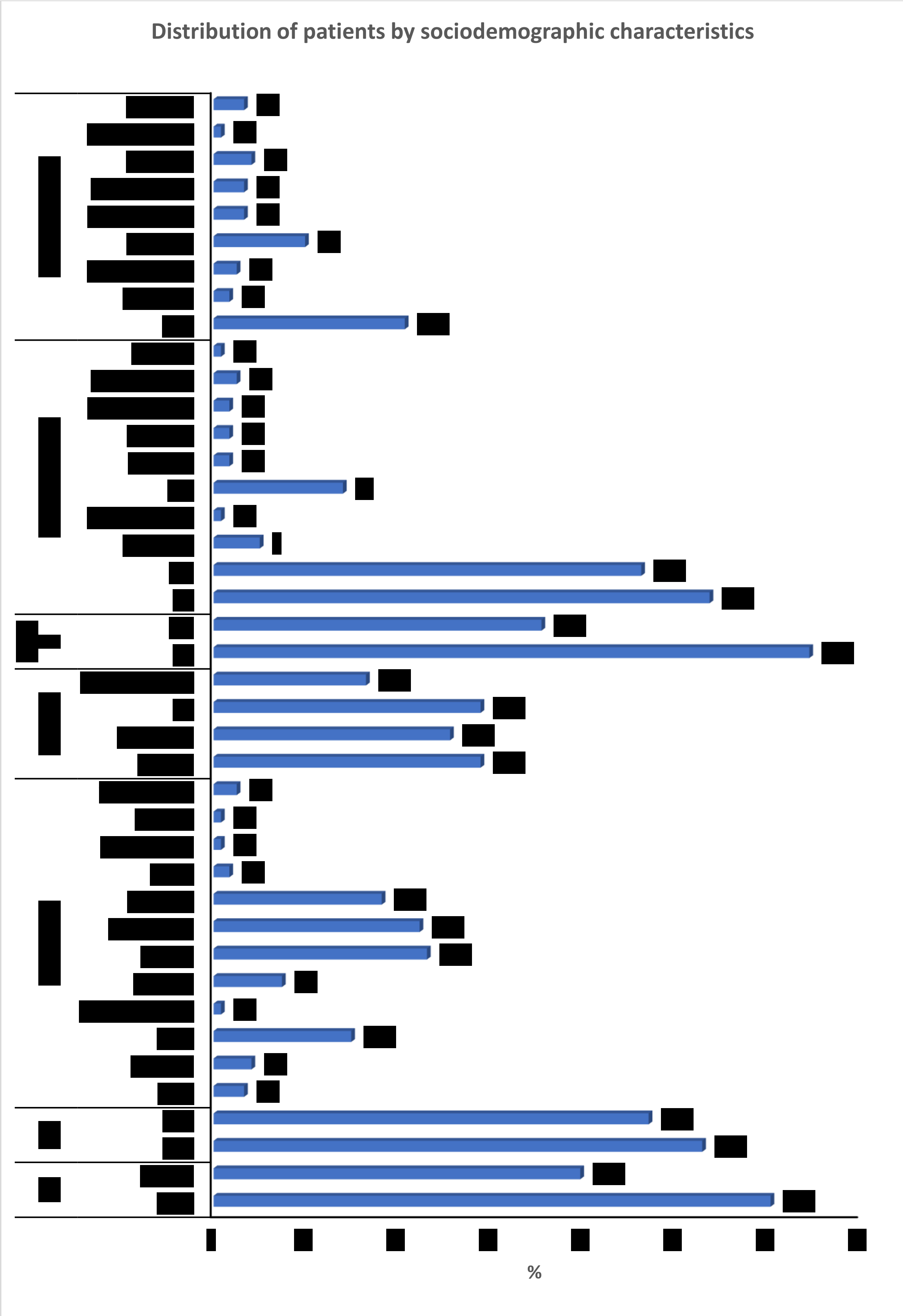
RESULTS

I – Descriptive Analysis

Table 1: Distribution of patients by sociodemographic characteristics

		n	%
Sex	**Male**	[redacted]	[redacted]
	Female	[redacted]	[redacted]
Age	**≤ 65**	[redacted]	[redacted]
	> 65	[redacted]	[redacted]
Occupation	**Bank**	[redacted]	[redacted]
	Businessmen	[redacted]	[redacted]
	Cook	[redacted]	[redacted]
	Engineer (Retd)	[redacted]	[redacted]
	Ex Army	[redacted]	[redacted]
	Farmer	[redacted]	[redacted]
	House Wife	[redacted]	[redacted]
	Labourer	[redacted]	[redacted]
	Police	[redacted]	[redacted]
	Stone Cutter	[redacted]	[redacted]
	Teacher	[redacted]	[redacted]
	Traffic Police	[redacted]	[redacted]
Smoking	**Current**	[redacted]	[redacted]
	Ex Smoker	[redacted]	[redacted]
	No	[redacted]	[redacted]
	Passive Smoker	[redacted]	[redacted]
Alcohol	**No**	[redacted]	[redacted]
	Yes	[redacted]	[redacted]
Biogas exposure	**No**	[redacted]	[redacted]
	Yes	[redacted]	[redacted]
COMORBIDITIES	**CVA, HTN**	[redacted]	[redacted]
	CVA, IHD, HTN	[redacted]	[redacted]
	DM	[redacted]	[redacted]
	DM, CVA	[redacted]	[redacted]
	DM, HTN	[redacted]	[redacted]
	DM, HTN, CVA	[redacted]	[redacted]
	DM, HTN, IHD	[redacted]	[redacted]
	DM, IHD	[redacted]	[redacted]
	HTN	[redacted]	[redacted]
	HTN, CVA	[redacted]	[redacted]
	HTN, CVA, IHD	[redacted]	[redacted]
	HTN, DM	[redacted]	[redacted]
	HTN, DM, CVA	[redacted]	[redacted]
	HTN, DM, IHD	[redacted]	[redacted]
	HTN, IHD	[redacted]	[redacted]
	HTN, IHD, CVA	[redacted]	[redacted]
	IHD, HTN	[redacted]	[redacted]

Graph 1: Distribution of patients by sociodemographic characteristics



[redacted]

[redacted]

[redacted]

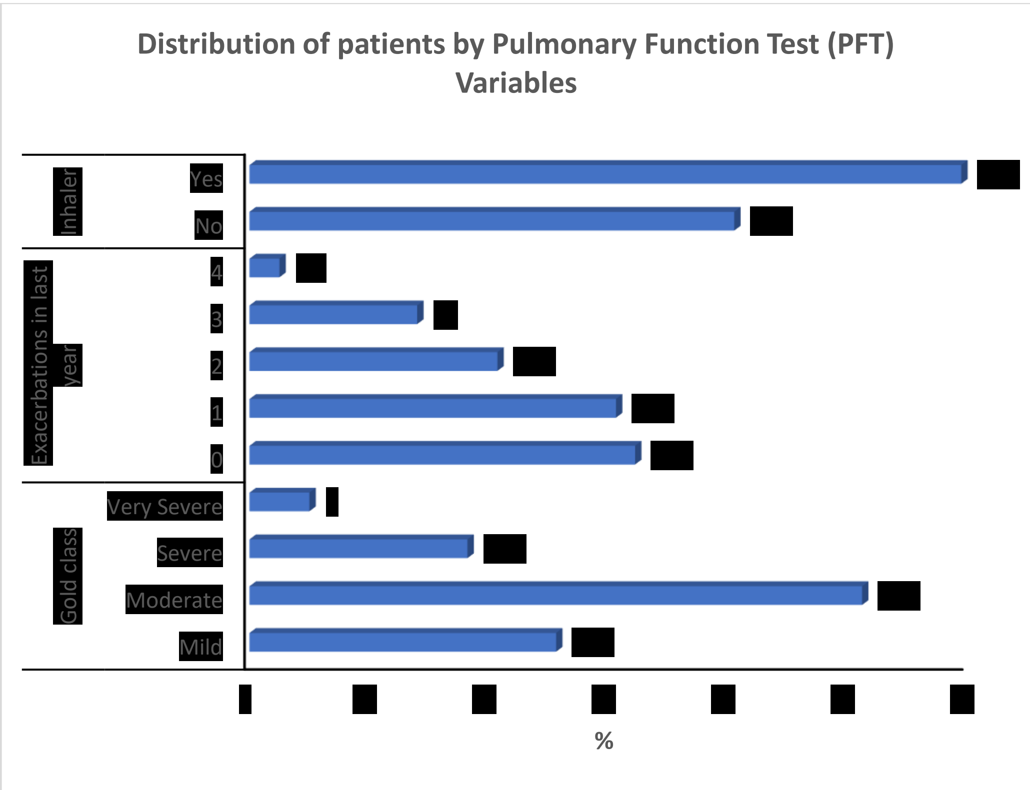
[redacted]

[redacted]

Table 2: Distribution of patients by Pulmonary Function Test (PFT) Variables

		n	%
Gold class	Mild	[redacted]	[redacted]
	Moderate	[redacted]	[redacted]
	Severe	[redacted]	[redacted]
	Very Severe	[redacted]	[redacted]
Exacerbations in last year	0	[redacted]	[redacted]
	1	[redacted]	[redacted]
	2	[redacted]	[redacted]
	3	[redacted]	[redacted]
	4	[redacted]	[redacted]
Inhaler	No	[redacted]	[redacted]
	Yes	[redacted]	[redacted]

Graph 2: Distribution of patients by Pulmonary Function Test (PFT) Variables



[redacted]

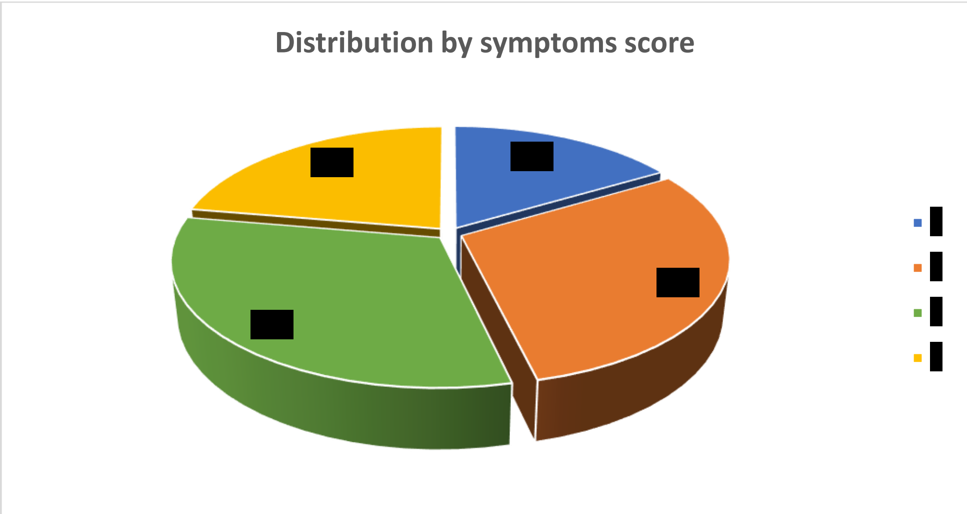
[redacted]

[redacted]

Table 3: Distribution by symptoms score

		n	%
MMRC Score	0	[redacted]	[redacted]
	1	[redacted]	[redacted]
	2	[redacted]	[redacted]
	3	[redacted]	[redacted]

Graph 3: Distribution by symptoms score



[redacted]

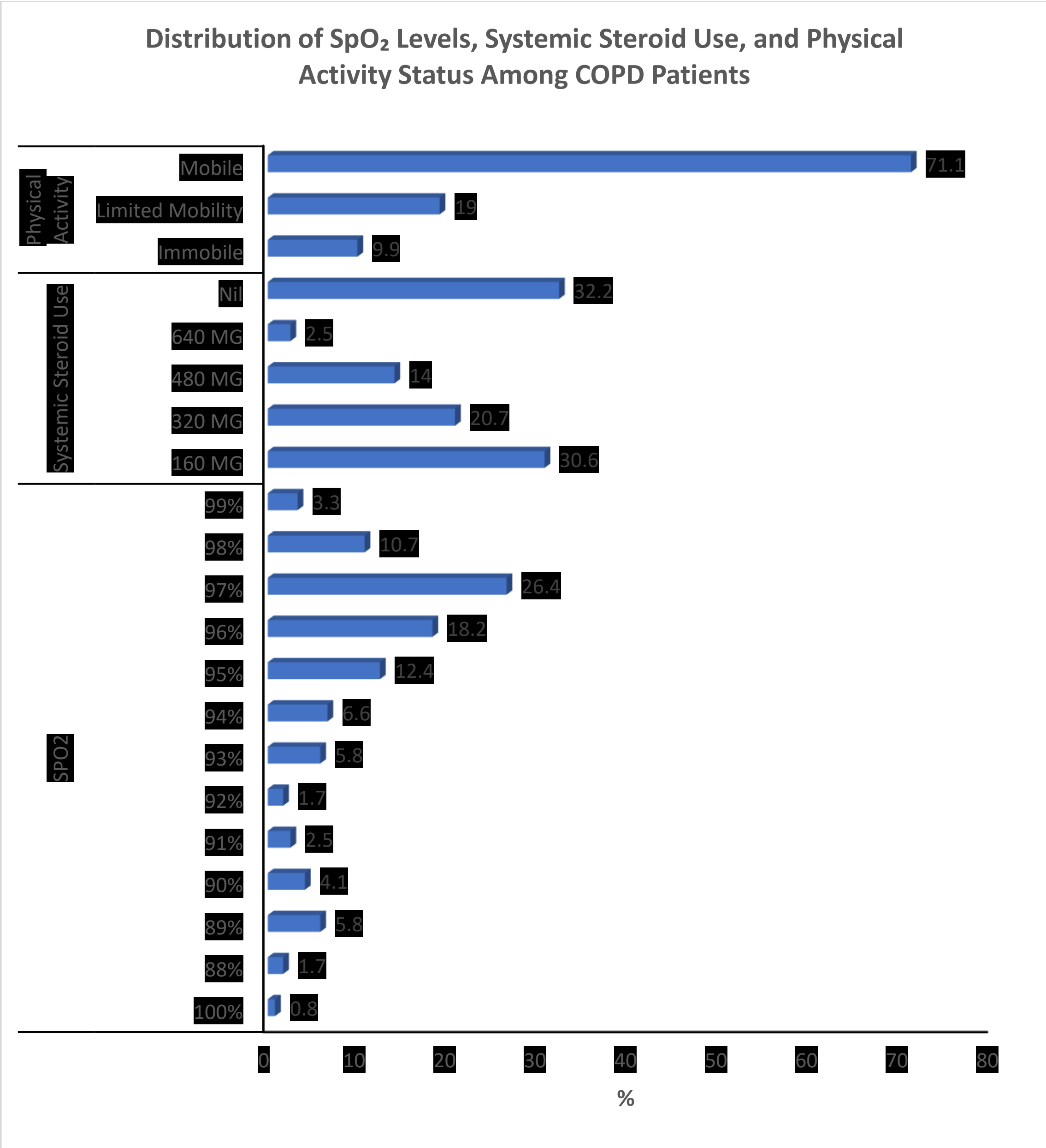
[redacted]

[redacted]

Table 4: Distribution of SpO_2 Levels, Systemic Steroid Use, and Physical Activity Status Among COPD Patients

		n	%
SPO2	100%	[redacted]	[redacted]
	88%	[redacted]	[redacted]
	89%	[redacted]	[redacted]
	90%	[redacted]	[redacted]
	91%	[redacted]	[redacted]
	92%	[redacted]	[redacted]
	93%	[redacted]	[redacted]
	94%	[redacted]	[redacted]
	95%	[redacted]	[redacted]
	96%	[redacted]	[redacted]
	97%	[redacted]	[redacted]
	98%	[redacted]	[redacted]
	99%	[redacted]	[redacted]
Systemic Steroid Use	160 MG	[redacted]	[redacted]
	320 MG	[redacted]	[redacted]
	480 MG	[redacted]	[redacted]
	640 MG	[redacted]	[redacted]
	Nil	[redacted]	[redacted]
Physical Activity	Immobile	[redacted]	[redacted]
	Limited Mobility	[redacted]	[redacted]
	Mobile	[redacted]	[redacted]

Graph 4: Distribution of SpO_2 Levels, Systemic Steroid Use, and Physical Activity Status Among COPD Patients



[redacted]

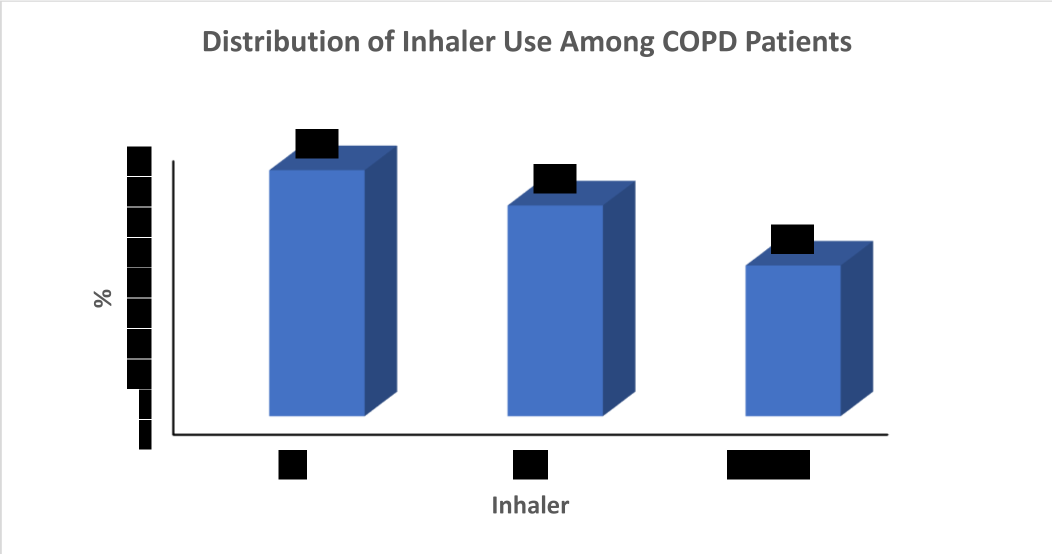
[redacted]

[redacted]

Table 5: Distribution of Inhaler Use Among COPD Patients

		n	%
Inhaler	No	[redacted]	[redacted]
	YES	[redacted]	[redacted]
	Yes (ICS)	[redacted]	[redacted]

Graph 5: Distribution of Inhaler Use Among COPD Patients



[redacted]

Table 6: Descriptive statistics of Pulmonary Function Test (PFT) Variables

	Mean	SD	Minimum	Maximum
FEV1	[redacted]	[redacted]	[redacted]	[redacted]
FVC	[redacted]	[redacted]	[redacted]	[redacted]
FEV1/FVC	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

Table 7: Descriptive statistics of symptoms score

	Mean	SD	Minimum	Maximum
SGRQ-S	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ-A	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ-I	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ- TOTAL	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 8: Descriptive statistics of Anthropometric Measurements

	Mean	SD	Minimum	Maximum
Height	[redacted]	[redacted]	[redacted]	[redacted]
Weight	[redacted]	[redacted]	[redacted]	[redacted]
BMI	[redacted]	[redacted]	[redacted]	[redacted]
MAC	[redacted]	[redacted]	[redacted]	[redacted]
TSF	[redacted]	[redacted]	[redacted]	[redacted]
CC	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 9: Descriptive statistics of Body Composition (Muscle/Fat Mass)

	Mean	SD	Minimum	Maximum
ASM	[redacted]	[redacted]	[redacted]	[redacted]
ASMI	[redacted]	[redacted]	[redacted]	[redacted]
FFM	[redacted]	[redacted]	[redacted]	[redacted]
FFMI	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted] The mean FFMI falls at the borderline cutoff, strongly indicating that muscle wasting is prevalent in this study population.

II – Data comparing demographic variables with Body Composition (Muscle/Fat Mass)

Table 10: Comparison of age by Body Composition (Muscle/Fat Mass)

Age		n	Mean	SD	t	p value
ASM	≤ 65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>65	[redacted]	[redacted]	[redacted]		
ASMI	≤ 65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>65	[redacted]	[redacted]	[redacted]		
FFM	≤ 65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>65	[redacted]	[redacted]	[redacted]		
FFMI	≤ 65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>65	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted] Additionally, FFMI showed a notable decline in the [redacted]-year group ([redacted]) when compared with the younger age group ([redacted]) ([redacted]).

Table 11: Comparison of gender by Body Composition (Muscle/Fat Mass)

SEX		n	Mean	SD	t	p value
ASM	Male	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Female	[redacted]	[redacted]	[redacted]		
ASMI	Male	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Female	[redacted]	[redacted]	[redacted]		
FFM	Male	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Female	[redacted]	[redacted]	[redacted]		
FFMI	Male	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Female	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

Table 12: Comparison of consumption of alcohol by Body Composition (Muscle/Fat Mass)

ALCOHOL		n	Mean	SD	t	p value
ASM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
ASMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

Table 13: Comparison of Biogas exposure by body mass consumption

BIOGAS EXPOSURE		n	Mean	SD	t	p value
ASM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
ASMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

[redacted]

Table 14: Comparison of smoking status by Body Composition (Muscle/Fat Mass)

		n	Mean	Std. Deviation	F	p-value
ASM	Current	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Ex-smoker	[redacted]	[redacted]	[redacted]		
	No	[redacted]	[redacted]	[redacted]		
	Passive smoker	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
ASMI	Current	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Ex-smoker	[redacted]	[redacted]	[redacted]		
	No	[redacted]	[redacted]	[redacted]		
	Passive smoker	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFM	Current	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Ex-smoker	[redacted]	[redacted]	[redacted]		
	No	[redacted]	[redacted]	[redacted]		
	Passive smoker	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFMI	Current	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Ex-smoker	[redacted]	[redacted]	[redacted]		
	No	[redacted]	[redacted]	[redacted]		
	Passive smoker	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

Table 15: Comparison of Gold class by Body Composition

		n	Mean	SD	F	p-value
ASM	Mild	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Moderate	[redacted]	[redacted]	[redacted]		
	Severe	[redacted]	[redacted]	[redacted]		
	Very severe	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
ASMI	Mild	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Moderate	[redacted]	[redacted]	[redacted]		
	Severe	[redacted]	[redacted]	[redacted]		
	Very severe	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFM	Mild	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Moderate	[redacted]	[redacted]	[redacted]		
	Severe	[redacted]	[redacted]	[redacted]		
	Very severe	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFMI	Mild	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Moderate	[redacted]	[redacted]	[redacted]		
	Severe	[redacted]	[redacted]	[redacted]		
	Very severe	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

[redacted]

In contrast, the differences in FFM [redacted] across severity classes were not statistically significant, indicating that total lean mass is less sensitive for detecting muscle loss than appendicular-focused indices.

Table 16: Comparison of EXACERBATIONS IN LAST YEAR by body composition

Exacerbations in Last Year		n	Mean	SD	F	p-value
ASM	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	4	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
ASMI	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	4	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFM	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	4	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFMI	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	4	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

FFMI exhibited a significant decline [redacted] from [redacted] in zero-exacerbation patients to [redacted] in patients with four exacerbations clearly reflecting greater muscle depletion with increasing disease instability.

Table 17: Comparison of INHALER Score by body composition

Inhaler		n	Mean	Std. Deviation	t	p-value
ASM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
ASMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFM	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		
FFMI	No	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Yes	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

Table 18: Comparison of MMRC Score by body composition

MMRC Score		n	Mean	SD	F	p-value
ASM	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
ASMI	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFM	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFMI	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	1	[redacted]	[redacted]	[redacted]		
	2	[redacted]	[redacted]	[redacted]		
	3	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		

[redacted]

[redacted]

[redacted]

Table 19: Comparison of BMI level by Body Composition (Muscle/Fat Mass)

		n	Mean	SD	F	p-value
ASM	<21	[redacted]	[redacted]	[redacted]		
	21-25	[redacted]	[redacted]	[redacted]		
	25-30	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>=30	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
ASMI	<21	[redacted]	[redacted]	[redacted]		
	21-25	[redacted]	[redacted]	[redacted]		
	25-30	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>=30	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFM	<21	[redacted]	[redacted]	[redacted]		
	21-25	[redacted]	[redacted]	[redacted]		
	25-30	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>=30	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		
FFMI	<21	[redacted]	[redacted]	[redacted]		
	21-25	[redacted]	[redacted]	[redacted]		
	25-30	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	>=30	[redacted]	[redacted]	[redacted]		
	Total	[redacted]	[redacted]	[redacted]		

[redacted] The

findings strongly emphasize that BMI [redacted] serves as a clinical red flag for severe sarcopenia in COPD patients and underscores the need for targeted nutritional rehabilitation and muscle-strengthening interventions in this high-risk subgroup.

Table 20: Comparison of Age wise (<=60 &>60) Body Composition (Muscle/Fat Mass) among male & female

Sex			n	Mean	SD	t	p-value
Female	ASM	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	ASMI	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	FFM	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	FFMI	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
Male	ASM	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	ASMI	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	FFM	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		
	FFMI	<=65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		>65	[redacted]	[redacted]	[redacted]		

[redacted]

Table 21: Comparison of Muscle Mass Indices Across Physical Activity Levels in COPD Patients

	IMMOBILE		LIMITED MOBILITY		MOBILE		Sig.
	Mean ±SD	Median ±IQR	Mean ±SD	Median ±IQR	Mean ±SD	Median ±IQR	
FFMI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ASMI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

***<0.05 significance is obtained by independent sample Kruskal Wallis test**

A statistically significant difference was found in muscle mass indices across different physical activity levels in COPD patients [redacted]

Table 22: Association of Gold class (Stage 1 & Stage 2) with body composition

	GOLD CLASS				t	p-value
	Stage 1 & 2		Stage 3 & 4			
	Mean	SD	Mean	SD		
ASM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
ASMI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
FFM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
FFMI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

***<0.05 significance is obtained by independent t test**

Patients were grouped into early-stage COPD (GOLD Stage 1 & 2) and advanced-stage COPD (GOLD Stage 3 & 4) to evaluate disease severity–related differences in muscle atrophy. [redacted]

[redacted]

Table 23: Correlation between Body Composition (Muscle/Fat Mass) & Pulmonary Function Test (PFT)

		ASM	ASMI	FFM	FFMI
FEV1	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
FVC	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
FEV1/FVC	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

Table 24: Correlation between symptom score and Body Composition (Muscle/Fat Mass)

		ASM	ASMI	FFM	FFMI
SGRQ-S	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ-A	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ-I	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
SGRQ-TOTAL	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

Table 25: Correlation between anthropometric measurement and Body Composition (Muscle/Fat Mass)

		ASM	ASMI	FFM	FFMI
Height	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
Weight	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
BMI	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
MAC	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
TSF	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
CC	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	r	[redacted]	[redacted]	[redacted]	[redacted]
	p-value	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 26: Systemic steroid use correlation with ASMI and FFMI

		Systemic steroid use
ASMI	r	[redacted]
	Sig.	[redacted]
FFMI	r	[redacted]
	Sig.	[redacted]

***<0.05 significance is obtained by Pearson's correlation coefficient.**

A statistically significant negative correlation was found between systemic steroid use and anthropometric markers of muscle mass in COPD patients. [redacted]

Table 27: Correlation between FFMI, ASMI with SPO2

		SPO2
FFMI	r	[redacted]
	Sig.	[redacted]
ASMI	r	[redacted]
	Sig.	[redacted]

***<0.05 significance is obtained by Pearson's correlation coefficient.**

A statistically significant positive correlation was observed between resting oxygen saturation and muscle mass parameters. [redacted] Therefore, maintaining adequate oxygenation may play an important role in preserving muscle health and functional status in this population.

Table 28: Multiple-Regression Analysis of Factors Associated with ASMI

Variable	B	Std. Error	t	Sig.
BMI	[redacted]	[redacted]	[redacted]	[redacted]
MAC	[redacted]	[redacted]	[redacted]	[redacted]
TSF	[redacted]	[redacted]	[redacted]	[redacted]
CC	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	[redacted]	[redacted]	[redacted]	[redacted]

[redacted] BMI and CC emerged as the most reliable, simple, and clinically useful indices for detecting skeletal muscle loss in COPD patients.

Table 29: Multiple-Regression Analysis of Factors Associated with FFMI

Variable	B	Std. Error	t	Sig.
BMI	[redacted]	[redacted]	[redacted]	[redacted]
MAC	[redacted]	[redacted]	[redacted]	[redacted]
TSF	[redacted]	[redacted]	[redacted]	[redacted]
CC	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	[redacted]	[redacted]	[redacted]	[redacted]

[redacted] BMI and CC emerged as strong positive indicators of muscle mass, while MAMA was inversely related, emphasizing their utility in assessing skeletal muscle atrophy in COPD patients.

III- Factors determining Skeletal Muscle atrophy in COPD

Table 30: Multiple regression analysis for prediction of ASMI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
	Smoking	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Biogas exposure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Comorbidities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Spo2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Physical activity	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Systemic steroid use	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Inhaler	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Gold class	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

a. Dependent Variable: ASMI

[redacted] Overall, this multivariate model highlights oxygenation status as the strongest determinant of appendicular muscle preservation in COPD, reinforcing the importance of early detection and correction of hypoxemia to prevent progressive skeletal muscle atrophy.

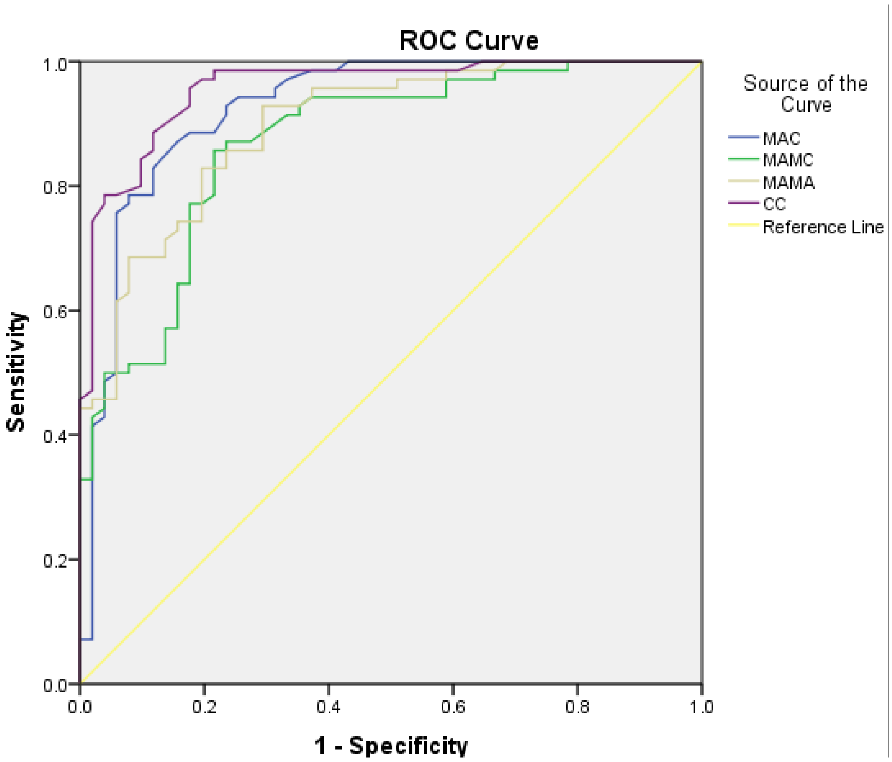
Table 31: Multiple regression analysis for prediction of FFMI

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
	Smoking	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Biogas exposure	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Comorbidities	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	SPO2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Physical activity	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Systemic steroid use	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Inhaler	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Gold class	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

a. Dependent Variable: FFMI

[redacted] Overall, this regression model reinforces that oxygen saturation is the strongest determinant of fat-free mass preservation in COPD patients, underscoring the importance of early identification and correction of hypoxemia to prevent progressive skeletal muscle atrophy and functional decline.

Table 32: Receiver Operating Characteristic (ROC) Analysis of Anthropometric Indicators for Predicting Normal FFMI

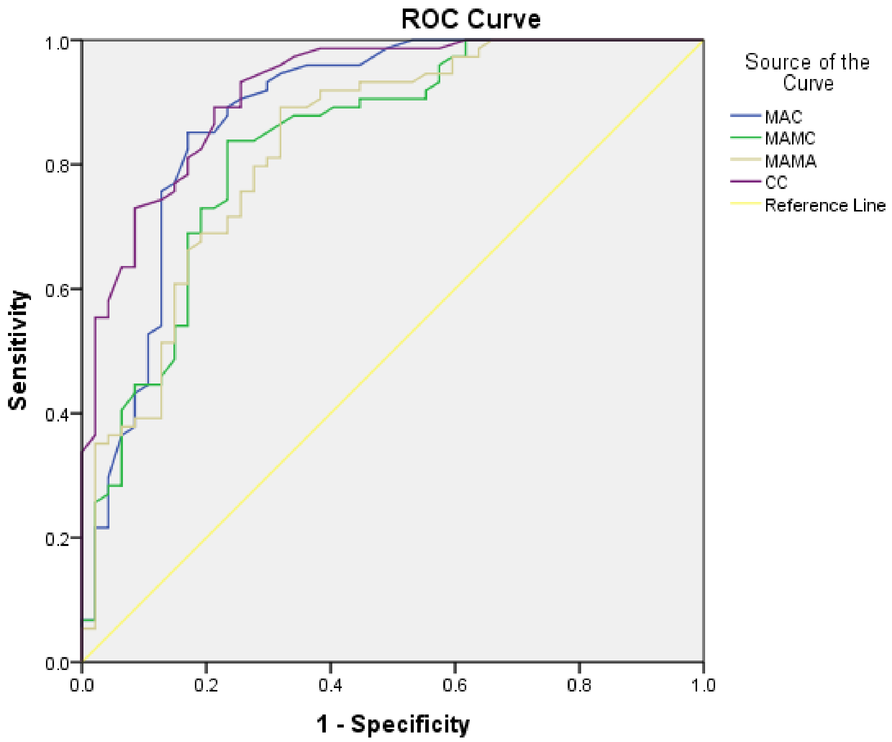


Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval		Cuttoff value	Sensitivity	Specificity
				Lower Bound	Upper Bound			
MAC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] Overall, these findings confirm that simple anthropometric measures particularly calf circumference and mid-arm circumference are highly accurate, practical, and reliable tools for detecting skeletal muscle atrophy in COPD patients, thereby strongly supporting their use as cost-effective bedside screening methods to identify individuals at high risk of sarcopenia and functional decline.

Table 33: Receiver Operating Characteristic (ROC) Analysis of Anthropometric Indicators for Predicting Normal ASMI



Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval		Cuttoff value	Sensitivity	Specificity
				Lower Bound	Upper Bound			
MAC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MAMC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
MAMA	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CC	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

[redacted] Overall, these findings confirm that simple anthropometric measurements particularly calf circumference and mid-arm circumference are effective, non-invasive tools for detecting reduced fat-free mass in COPD patients and can be reliably used for early identification of muscle depletion in routine clinical practice.

DISCUSSION

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is now recognized as a systemic disorder in which skeletal muscle dysfunction and nutritional depletion significantly influence functional capacity, exacerbation risk, quality of life, and survival. [redacted]

[redacted]

Anthropometric Measurements

The anthropometric profile of the present COPD cohort demonstrates substantial variability in nutritional and muscle-related indices, reflecting heterogeneous body composition changes in chronic respiratory disease. [redacted]

[redacted]

[redacted] Overall, these anthropometric findings support the concept that peripheral measurements are more sensitive than BMI for detecting skeletal muscle atrophy in COPD.

Body Composition (Muscle and Fat Mass)

The body composition analysis revealed a mean ASMI of [redacted] and FFMI of [redacted], values that approach or fall below established cut-offs for muscle depletion, particularly in males (ASMI [redacted] (men) indicates low muscle mass, FFMI [redacted] (men) indicates muscle depletion). [redacted]

[redacted]

[redacted] The present results reinforce that ASMI and FFMI are reliable markers of skeletal muscle atrophy and should be prioritized over BMI when assessing nutritional and muscular status in COPD.

Correlation between Anthropometric Measurements and Body Composition (ASM/ASMI/FFM/FFMI)

In the present study, it directly addresses the primary objective: whether simple anthropometric indices reflect skeletal muscle mass in COPD. [redacted]

[redacted]

[redacted]

[redacted]

[redacted] Overall, the present study provides strong internal evidence that the evaluated anthropometric indices particularly CC, BMI, and MAC-based measures are meaningfully associated with skeletal muscle mass indices in COPD.

Multiple Regression Analysis of Anthropometric Predictors of ASMI

The present study, aimed at establishing the most reliable anthropometric index which can independently predict ASMI after accounting for overlap between measures. [redacted]

[redacted]

[redacted]

[redacted]

In COPD, where muscle loss is a major systemic manifestation linked to outcomes (Schols et al. 2005), provides actionable information: BMI + calf circumference appears to be the most efficient anthropometric combination for estimating appendicular muscle status (ASMI) in routine practice [80].

Multiple Regression Analysis of Anthropometric Predictors of FFMI

In the present study, analysis to whole-body lean mass indexed to height (FFMI), showing that BMI and calf circumference again remain significant positive predictors, while MAMA shows a statistically significant association in the model. [redacted]

[redacted] The present findings suggest that simple anthropometry can independently capture risk for reduced FFMI.

The consistent independent role of **CC** again supports the lower-limb focus of COPD-related wasting and functional deconditioning (Gea et al. 2015; Iepsen and Pedersen 2020) [3,71]. [redacted]

[redacted]

[redacted]

[redacted]

ROC Analysis of Anthropometric Indicators for Predicting Normal ASMI

In the present study, diagnostic accuracy of selected anthropometric indices in identifying normal appendicular skeletal muscle mass index (ASMI), which is a direct marker of limb muscle preservation and a sensitive indicator of sarcopenia in COPD. [redacted]

[redacted]

[redacted]

[redacted]

[redacted] Overall, strong, clinically actionable evidence that calf circumference and mid-arm circumference are accurate, low-cost, and practical screening tools for appendicular skeletal muscle atrophy in COPD, particularly valuable in routine outpatient and resource-limited settings where advanced body composition techniques are unavailable.

ROC Analysis of Anthropometric Indicators for Predicting Normal FFMI

In the present study, clinical translation by evaluating how well simple anthropometric measures discriminate patients with normal FFMI. [redacted]

[redacted]

[redacted]

[redacted]

Study	Study Population	Sample Size (n)	Muscle / Anthropometric Assessment	Study Design	Key Outcome Related to Muscle Atrophy
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Age-wise Comparison of Body Composition

The age distribution showed nearly equal representation of patients [redacted], indicating that COPD affects both late-middle-aged and elderly populations. [redacted]

[redacted]

[redacted]

These findings highlight elderly COPD patients as a high-risk subgroup for muscle wasting, warranting early nutritional assessment and targeted interventions.

Gender-wise Comparison of Body Composition (ASM/ASMI/FFM/FFMI)

The present study demonstrated a male predominance among COPD patients [redacted] which is consistent with the epidemiological profile of COPD reported in Indian and global studies. [redacted]

[redacted]

Alcohol Consumption and Body Composition

In the present study, alcohol consumers showed significantly higher ASM and FFM compared to non-consumers, while ASMI and FFMI did not differ significantly. [redacted]

[redacted]

Biogas Exposure and Body Composition

In the present cohort, biogas exposure was associated with significantly higher ASMI and FFMI, while ASM and FFM did not show significant differences. This mixed pattern suggests that exposure status may be linked to body-size-normalized muscle indices rather than absolute muscle mass, and may also reflect lifestyle differences [redacted] Table 11 strengthens the rationale for adjusted regression analyses in this study.

Smoking Status and Body Composition

Smoking exposure was present in [redacted] of patients either directly or passively, corroborating findings by Bhatt et al. [redacted]

[redacted]

[redacted] Thus, the present study, highlights the importance of focusing on disease-related and functional determinants rather than smoking status alone when evaluating muscle atrophy in COPD.

Correlation Between Pulmonary Function and Body Composition

The pulmonary function profile of the study population demonstrated a mean FEV_1 of [redacted] indicating predominantly moderate airflow limitation. [redacted]

[redacted]

[redacted]

[redacted] The present correlations support a physiological link between respiratory impairment and muscle atrophy, reinforcing the relevance of integrating pulmonary function assessment with muscle evaluation when managing COPD patients.

GOLD Severity Class and Body Composition

In the present study, ASM and ASMI showed a statistically significant decline with increasing GOLD severity, while FFM and FFMI did not vary significantly across stages. [redacted] In the present study, the use of appendicular muscle indices for detecting COPD severity-related muscle atrophy, aligns with the study's objective of identifying sensitive indicators of skeletal muscle loss in COPD.

GOLD Stage Grouping (Stage 1–2 vs Stage 3–4) and Body Composition

When COPD patients were grouped into early (GOLD stage 1–2) and advanced disease (GOLD stage 3–4), muscle mass indices were consistently lower in advanced stages, although the differences did not reach statistical significance. [redacted]

[redacted] In the present study, skeletal muscle atrophy in COPD is multifactorial and cannot be predicted reliably by airflow limitation severity alone.

Exacerbations in the Previous One Year and Body Composition

The present study demonstrated a clear and statistically significant decline in ASM, ASMI, and FFMI with increasing frequency of COPD exacerbations, indicating that disease instability strongly contributes to skeletal muscle atrophy. [redacted]

Inhaler Use and Body Composition

In the present study, patients not using inhalers demonstrated significantly higher ASM, ASMI, FFM, and FFMI compared to those receiving inhaler therapy. [redacted]

[redacted] The findings underscore the importance of addressing muscle health proactively in symptomatic COPD patients receiving inhaler therapy through exercise training and nutritional optimization.

mMRC Dyspnea Score and Body Composition

Dyspnea severity assessment using the mMRC scale revealed that more than half of the study population ([redacted]) experienced moderate to severe breathlessness (mMRC grades 2–3). [redacted]

[redacted] Thus, the present findings reinforce dyspnea severity as a key clinical marker for identifying COPD patients at high risk of skeletal muscle loss and underline the importance of incorporating symptom-based assessment into muscle screening strategies.

Correlation Between SGRQ Scores and Body Composition

The present study demonstrated markedly elevated SGRQ scores across all domains, with a mean total score of [redacted], indicating moderate to severe impairment in health-related quality of life. [redacted]

[redacted]

[redacted] Thus, the present correlations confirm that muscle atrophy in COPD is not merely a physiological abnormality but is closely tied to patient-perceived disease burden and functional impairment.

BMI Categories and Body Composition

In the present study, all muscle mass indices increased progressively across higher BMI categories, with patients having BMI [redacted] showing markedly lower ASM, ASMI, FFM, and FFMI, indicating severe muscle depletion. [redacted] The present findings underscore that BMI [redacted] represents a high-risk threshold for severe muscle atrophy, but comprehensive assessment using appendicular indices and anthropometric measures is essential for accurate identification of skeletal muscle loss in COPD.

Age-wise Body Composition among Male and Female COPD Patients

In the present study, a clear sex-specific pattern in age-related muscle decline. [redacted]

[redacted] In the present study, the rationale for targeted screening and early rehabilitation in elderly male COPD patients to mitigate accelerated muscle loss.

Distribution of Inhaler Use (No Inhaler vs Non-ICS Inhaler vs ICS-based Inhaler)

In the present study, heterogeneity in pharmacological management, with a large proportion not using inhalers and a smaller but substantial subset receiving inhaled therapy, including ICS-based regimens. [redacted]

[redacted]

[redacted] The findings support integrating muscle screening and rehabilitation particularly in patients requiring escalated inhaler therapy or those who remain symptomatic due to non-treatment.

Correlation between SpO_2 and Muscle Mass Indices (ASMI and FFMI)

The present study demonstrated a statistically significant positive correlation between resting oxygen saturation (SpO_2) and both ASMI and FFMI, with a stronger association observed for ASMI. [redacted]

[redacted]

[redacted] In the present study, strong evidence that impaired oxygenation is closely linked with skeletal muscle depletion, particularly appendicular muscle loss, underscoring the importance of early detection and correction of hypoxemia to preserve muscle mass in COPD patients.

Physical Activity Levels and Muscle Mass Indices

In the present study, a statistically significant reduction in both ASMI and FFMI across decreasing physical activity levels, with immobile patients exhibiting the lowest muscle mass indices. [redacted]

[redacted]

[redacted] In the present study, strong evidence that reduced physical activity is a key driver of skeletal muscle loss in COPD and supports early initiation of structured exercise and rehabilitation programs to prevent sarcopenia and functional decline.

Systemic Steroid Use and Muscle Mass Indices

The present study showed a statistically significant negative correlation between cumulative systemic steroid use and both ASMI and FFMI, indicating that higher steroid exposure is associated with greater skeletal muscle depletion. [redacted]

Multiple Regression Analysis to determine the clinical and environmental predictors of ASMI (Clinical and Environmental Predictors)

In the present study, independent predictors of ASMI after adjustment for multiple clinical and exposure variables were determined. [redacted]

[redacted]

[redacted]

[redacted] In the present study, oxygenation status as the most actionable biological determinant of appendicular muscle preservation in COPD.

Multiple Regression Analysis to determine the clinical and environmental predictors of FFMI (Clinical and Environmental Predictors)

In the present study, multivariable approach to FFMI, a clinically important index reflecting whole-body lean mass depletion. [redacted]

[redacted]

[redacted] In the present study, oxygenation status is the dominant independent clinical correlate of lean mass preservation in this COPD cohort, supporting routine SpO_2 monitoring as part of muscle atrophy risk stratification.

STRENGTHS AND LIMITATIONS

STRENGTHS OF THE STUDY

1. Comprehensive evaluation of skeletal muscle atrophy using both body composition indices (ASM, ASMI, FFM, FFMI) and simple anthropometric measurements, allowing direct comparison between advanced and bedside assessment methods.

[redacted]

7. High clinical relevance for resource-limited settings, where advanced imaging or body composition tools may not be routinely available.

LIMITATIONS OF THE STUDY

1. Cross-sectional study design, which limits the ability to establish causal or temporal relationships between anthropometric indices and skeletal muscle atrophy.

[redacted]

8. Possibility of residual confounding from unmeasured variables such as inflammatory markers, hormonal status, or long-term medication adherence.

CONCLUSION

CONCLUSION

This study demonstrates that skeletal muscle atrophy is highly prevalent among patients with chronic obstructive pulmonary disease and is closely associated with multiple clinical, functional, and anthropometric factors. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] Early detection, combined with targeted interventions such as optimization of oxygenation, pulmonary rehabilitation, nutritional support, and judicious use of systemic steroids, may help preserve muscle mass, improve functional capacity, and ultimately enhance quality of life and outcomes in patients with COPD.

SUMMARY

SUMMARY

This study highlights that skeletal muscle atrophy is a common and clinically important manifestation of chronic obstructive pulmonary disease, often occurring even in patients with normal body mass index. [redacted]

[redacted]

[redacted]

[redacted]

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[redacted]

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ANNEXURES

ANNEXURES-I

[redacted]

Name of Student/Principal Investigator:

Name of Guide/Co Investigators:

Introduction:

Explanation of procedure:

In simple language, [redacted]

Privacy and confidentiality: [redacted]

Financial incentives: [redacted]

Cost of investigations [redacted]

Authorization for publication of aggregated data: [redacted]

Questions: [redacted]

Legal rights: By signing this consent form, we are not waving any ofyour legal rights

[redacted]

Name ofthe participant:

Signature or left thumb impression ofthe participant:

Name ofthe witness:

Signature or left thumb impression ofthe witness:

Name ofthe investigator:

Signature ofthe investigator:

ANNEXURES-II

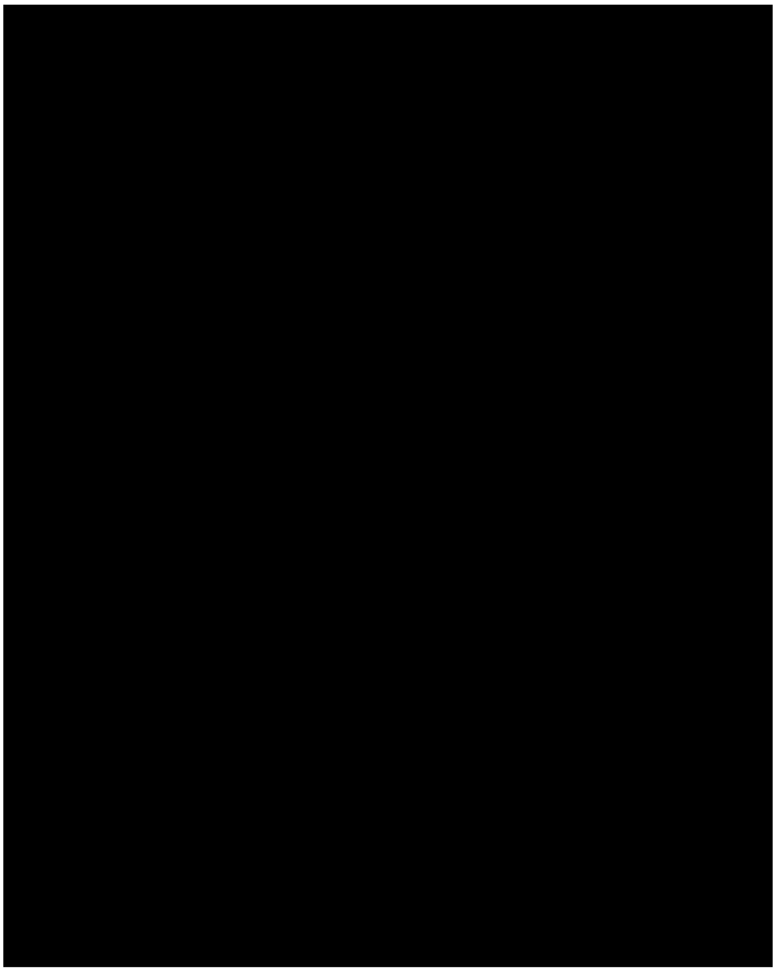
PROFORMA

Clinical Photos

[redacted]

[redacted]

Values seen on machine



Values seen on Phone

MASTER CHART

OP NO	AGE	SEX	Occupation	SMOKING	ALCOHOL	BIOGAS EXPOSURE	COMORBIDITIES	FEV1	FVC	FEV1/FVC	GOLD CLASS	PHYSICAL ACTIVITY	EXACERBATIONS IN LAST YEAR	SYSTEMIC STEROID USE	INHALER	SPO2	MMRC SCORE	SGRQ-S	SGRQ-A	SGRQ-I	SGRQ- TOTAL	HEIGHT	WEIGHT	BMI	MAC	TSF	CC	MAMC	MAMA	ASM	ASMI	FFM	FFMI
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