CORRELATION BETWEEN CHEST EXPANSION AND COUGH FUNCTION IN CRITICALLY ILL PATIENTS IN A TERTIARY HEALTH INSTITUTION

BY

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CERTIFICATION

This dissertation by **ABDULHAMID AMIRA** is accepted in its present form as satisfying dissertation requirement of the degree of the degree of Bachelor of Physiotherapy of the School of Basic Medical Sciences of the University of Benin.

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DEDICATION

This dissertation is dedicated to Allah who has made everything possible, to myself for my unwavering resilience, and to my parents Mr. and Mrs. ABDULHAMID IDRIS, who made this work a reality through their constant support.

ABSTRACTS

Background: Chest expansion and cough function are essential in managing critically ill patients. Chest expansion reflects respiratory muscle strength and lung compliance, assessed non-invasively using simple measurements. Cough function clears airway secretions and prevents complications like pneumonia, but it is often impaired in critically ill patients due to immobility and weakened respiratory mechanics. Exploring the relationship between chest expansion and cough function could enable better, non-invasive methods to assess and improve respiratory health in this population.

Methods: This study employs a cross-sectional design to explore the relationship between chest expansion and cough function in critically ill patients. Participants were selected using a purposive sampling technique based on specific inclusion criteria. A sample size of 34 was determined through a power analysis, ensuring adequate statistical power to detect significant correlations.

Results: This study included 34 participants (58.8% female, 41.2% male) with a mean age of 53. No significant correlations were found between cough function and chest expansion at any level ($p > 0.05$). However, a significant negative correlation was observed between age and cough function ($r = -0.906$, $p = 0.021$). Hypothesis testing confirmed no significant relationship between chest expansion and cough function but identified a decline in cough function with increasing age.

Conclusion: This study explored the relationship between chest expansion and cough function in critically ill patients. Chest expansion, a non-invasive measure of respiratory mechanics, and cough function, essential for airway clearance, were evaluated in 34 participants with an average age of 53 years. While no significant correlation was found between chest expansion at any level and cough function, a negative correlation between age and cough function was observed, indicating a decline in cough effectiveness with advancing age. Gender differences were noted in chest expansion at the axilla and xiphoid levels, with males showing greater values, but no gender-based differences were observed in cough function.

Keywords: Chest expansion measurements, cough function, critically ill patients, the University of Benin Teaching Hospital (UBTH).

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Chest expansion and cough function are critical physiological indicators in the management of critically ill patients (Longhini *et al.*, 2020). Chest expansion plays a role in effective lung ventilation and oxygenation and denotes the quantifiable increase in the sizes of the thoracic (chest) and abdominal regions during inhalation (inspiration) (Padkao and Boonla, 2020). This increase is a vital indicator of the mobility and elasticity of the chest wall, which comprises the rib cage, sternum, associated musculature, and the underlying pulmonary structures, primarily the lungs (Higashino, et al.,2022). Chest expansion measurement is a valuable and widely utilized method for evaluating respiratory function (Longhini *et al.*, 2020). This technique involves measuring the difference in thoracic or abdominal circumference between full inhalation and full exhalation, effectively assessing the mechanical capabilities of the respiratory muscles in expanding and contracting the chest (Tsui *et al.*, 2023). The diaphragm and external intercostal muscles serve as the primary respiration muscle (LoveLocal, 2023). When individuals are confined in bed for an extended period, the muscles involved in respiration can weaken due to disuse, limiting their strength and coordination, examining chest expansion at various levels, physiotherapists can achieve a more comprehensive understanding of the diaphragmatic function and overall respiratory mechanics (Pathmanathan et al., 2015). This holistic approach can lead to more informed assessments and enhance patient care. (LoveLocal, 2023). Measuring chest expansion is an essential clinical practice that provides valuable insight into the functional capacity of the respiratory system. This can be conducted through a simple, non-invasive, and cost-effective method for evaluating thoracic mobility using a tape measurement at specific anatomical landmarks like the axillary, xiphoid and subcostal or umbilicus levels. Regular evaluation of chest expansion helps identify early signs of respiratory dysfunction, monitor disease progression, and assess the effectiveness of physiotherapeutic intervention (Nair et al., 2021). In summary, chest expansion is a vital physiological function influenced by the interplay of respiratory muscle strength, lung compliance, airway patency, neurological status, and the effects of prolonged immobility. Its measurement is crucial in a clinical setting, offering critical insights into a patient's respiratory health and aiding in the management of various pulmonary, neurological, and musculoskeletal conditions. Understanding the mechanisms and implications of chest expansion is essential for healthcare professionals in delivering effective respiratory care and improving patient outcomes.

On the other hand, cough function is essential for clearing airway secretions, and preventing complications such as pneumonia and atelectasis, which are common in critically ill patients (Borges, 2023). Patients in critical care often experience compromised respiratory mechanics due to factors such as prolonged immobility, sedation, mechanical ventilation, and underlying conditions like chronic obstructive pulmonary disease (COPD) or neuromuscular disorders (Iavarone *et al.*, 2024). These factors can lead to reduced chest wall mobility and ineffective cough reflex, further exacerbating respiratory complications. This can lead to decreased chest wall mobility and diminished lung capacity, increasing the risk of respiratory complications such as atelectasis (collapse of lung tissue). Furthermore, the accumulation of secretions in the lungs due to inactivity can further inhibit effective chest expansion and overall respiratory function. Clinically, reduced chest expansion is a hallmark sign of various pulmonary, neurological, and musculoskeletal disorders. In the context of conditions like COPD and interstitial lung disease, reduced chest expansion is indicative of compromised lung function. In neuromuscular disorders such as muscular dystrophies, respiratory muscle weakness leads to diminished chest expansion, while prolonged immobility can exacerbate this issue by decreasing overall respiratory capacity. Cough Function is essential for maintaining pulmonary hygiene, facilitating the clearance of secretions, and preventing respiratory complications in critically ill patients(Pitts *et al.*, 2019). The inability to produce a strong and effective cough can lead to mucus retention, atelectasis, and an increased risk of pneumonia, all of which can exacerbate the condition of critically ill patients and extend their intensive care treatments. Hence, assessing and enhancing cough function is a critical component of respiratory care in these patients that a physiotherapist must carry out in clinical practice (Button and Button, 2013). Traditionally, the assessment of cough function has relied on clinical observations, subjective measures, and various objective parameters such as peak cough flow (PCF) and maximum expiratory pressure (MEP). These measures, while useful, can be challenging to perform in critically ill patients due to factors like sedation, mechanical ventilation, and overall weakness. Consequently, there is a need for alternative, non-invasive, and easily applicable methods to assess respiratory function and cough function in this patient population(Jia *et al.*, 2021).

Exploring the relationship between chest expansion and cough function holds significant clinical promise. A strong correlation would confirm chest expansion as a dependable, non-invasive method for evaluating cough strength and effectiveness in critically ill patients. This advancement could facilitate more frequent and precise monitoring of respiratory function, allowing for prompt interventions that enhance pulmonary hygiene and diminish the risk of respiratory complications(Shōbo and Kakizaki, 2014). Furthermore, this research could pave the way for developing targeted respiratory therapies aimed at enhancing lung compliance and, consequently, cough effectiveness. Interventions such as deep breathing exercises, respiratory muscle training, and specific physiotherapeutic techniques could be evaluated and optimized based on their impact on chest expansion and cough function(Kaneko, Suzuki and Horie, 2019).

1.1 Statement of the problem

Critically ill patients often present with compromised respiratory function, which can lead to life-threatening complications if not properly managed (Pathmanathan et al., 2015). Reduced chest expansion and impaired cough reflex are common in this population, increasing the risk of mucus retention, atelectasis, and pneumonia. Despite the importance of these physiological factors, there is limited evidence establishing a direct correlation between chest expansion measures and cough function in critically ill patients. Recent research has shown that reduced chest expansion during prolonged intensive care is associated with a higher incidence of ineffective cough and subsequent respiratory issues, including pneumonia (Longhini *et al.*, 2020). Understanding this correlation could provide healthcare professionals with a simple and non-invasive tool to assess cough function, improving respiratory care and outcomes for these patients.

1.1 Research Questions

The study will answer the following research questions:

- **I.** Is there a correlation between chest expansion measures at the axilla level and the cough function in critically ill patients?
- **II.** Is there a correlation between chest expansion measures at the xiphoid level and cough function in critically ill patients?

III. Is there a correlation between chest expansion measures at the umbilicus level and cough function in critically ill patients?

IV. Will chest expansion predict cough function in critically ill patients?

1.2 Aim of study

To determine the correlation between chest expansion measures and cough function in critically ill patients as well as to explore if chest expansion will predict cough function.

1.4.1 Specific objectives

I. To investigate the correlation between chest expansion measures and cough function in critically ill patients.

II. To determine if the chest expansion at the three levels will predict cough function in critically ill patients.

1.3 Hypotheses

1.5.1 Main hypotheses

I. There is no significant correlation between chest expansion measures and cough function in critically ill patients.

II. Chest expansion measures will not predict cough function in critically ill patients

1.5.2 Sub Hypotheses

II. There is no significant correlation between chest expansion measures at the Axilla and cough function in critically ill patients.

III. There is no significant correlation between chest expansion measures at the xiphoid and cough function in critically ill patients.

IV. There is no significant correlation between chest expansion measures at the umbilicus and cough function in critically ill patients.

V. Chest expansion measures at the Axilla level will not predict cough function in critically ill patients.

VI. Chest expansion measure at the xiphoid level will not predict cough function in critically ill patients.

VII. Chest expansion measure at the umbilical level will not predict cough function in critically ill patients.

1.6 Scope of the study

The scope of this study encompasses;

I. Critically ill patients in the critical bays of all the general wards in the University of Benin Teaching Hospital.

II. Measurements of chest expansion at the Axilla, the Xyphoid, and Umbilicus levels.

III. Measurements of cough function using the Semi-quantitative cough strength score.

IV. Critically ill patients aged 18 years and above.

1.7 Significance of the study

I. **Improved Respiratory Management**: By establishing a correlation between chest expansion and cough function, this study can help healthcare professionals develop more targeted respiratory interventions for critically ill patients, reducing complications like pneumonia and atelectasis.

II. **Enhanced Physiotherapy Strategies**: Findings from this research can guide physiotherapists in designing effective rehabilitation programs that focus on improving chest expansion and cough efficiency, leading to better secretion clearance and respiratory function.

III. **Early Detection of Respiratory Decline**: Identifying a link between chest expansion and cough function can provide an early diagnostic tool for detecting respiratory deterioration, allowing for timely interventions before severe complications arise.

IV. **Evidence-Based Clinical Practice**: This study will contribute to the existing body of knowledge by providing scientific evidence on the relationship between chest expansion and cough function, helping clinicians make informed decisions in managing critically ill patients.

V. **Reduction in Morbidity and Mortality**: Optimizing chest expansion and cough function in critically ill patients can significantly reduce the risk of respiratory infections and improve overall patient outcomes, potentially lowering ICU-related mortality rates.

1.8 Limitations of the study

I. The study was conducted among critically ill patients so the relatively small and specific sample size could affect the findings compared to a larger population.

II. The study was conducted in a relatively under-researched area, with few related studies, articles, and publications available. This limited the ability to compare findings with existing literature and posed challenges in identifying established methodologies or benchmarks for measurement.

III. The study relied on the Cough Strength Score as a measure of cough effectiveness instead of a Cough Peak Flow Meter, which could have provided more objective and accurate measurements. This substitution may have introduced subjectivity and limited the precision of the data collected.

1.9 Definition of terms

I. **Chest Expansion:** The difference in the circumference of the chest or thoracoabdominal region between maximum inhalation and maximum exhalation, indicating the ability of the chest to expand and contract during breathing.

II. **Effective Cough:** A cough that successfully clears the airways of secretions and foreign particles, typically assessed by peak cough flow (PCF) and subjective observations by healthcare providers.

III. **Critically Ill Patients:** Critically ill patients who are conscious and alert individuals requiring specialized monitoring and care in the critical bays of general wards at a tertiary health institution. This group includes those with severe infections like sepsis, individuals experiencing respiratory distress but still breathing on their own without depending on mechanical ventilation, patients with cardiac failure that affects blood flow, and alert trauma patients who are hemodynamically stable but still need close observation for potential complications.

IV. **Cough Strength Score (CSS):** is a clinical assessment tool used to evaluate the effectiveness and strength of a patient's cough. It is typically based on subjective observation of the sound, force, and ability of the patient to generate a productive or forceful cough. The score is often graded on a scale (0–5), with higher scores indicating a stronger, more effective cough and lower scores reflecting a weak or absent cough effort.

1.10 List of Abbreviations

- ICU: Intensive Care Unit
- CSS: Cough strength score
- CIP: Critically ill patients
- SIP: Sub-acutely ill patients
- RR: Respiratory Rate
- COPD: Chronic Obstructive Pulmonary Disease
- MV: Mechanical Ventilation
- SPO2: Peripheral Capillary Oxygen Saturation

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

2.1.1 Consciousness and Care Spectrum in Critical Illness

Critically ill patients are not necessarily unconscious (Vergnano *et al.*, 2023). Critical illness refers to a condition where a patient is at risk due to severe injury or organ failure, requiring close monitoring and intensive medical care. While they may be unconscious due to their conditions and treatments, many are conscious but would still require intensive interventions (consciously critically ill patients). Conscious critically ill patients may include; patients with severe infections like sepsis, respiratory distress with auto or mechanical breathing assistance, cardiac failure, and Trauma patients who are alert and hemodynamically stable. Another study explored the psychological experiences of conscious intubated patients in the ICU. Participants reported feelings of fear, anxiety, helplessness, and despair due to communication barriers caused by intubation. This highlights that critical illness does not always equate to unconsciousness; many patients remain aware and experience significant psychological challenges during their treatment (Nasiri *et al.*, 2024).

Critical care is a spectrum and not all critical patients are placed in the ICU (Christensen and Liang, 2023). Numerous patients are admitted to the critical care bays located within general wards, which serve a vital role in hospital patient management (Plate, J, et al,. (2017). Generally, patients within the regular general wards are categorized as sub-acutely ill, reflecting their status as individuals who are in a transitional state of recovery. In contrast, patients who are situated in the critical care bays are typically not classified as sub-acutely ill unless they are undergoing a specific recovery phase after a critical condition. The term “sub-acutely ill” has specific and significant clinical implications. It encompasses patients who are in the recovery process from either a critical illness or an acute medical event. These patients are characterized by their relative instability; they are no longer critically ill, yet they still demand attentive care and close monitoring as they navigate this transitional phase. Within the context of critical care, patients may be categorized as Critically ill Patients (CIP) or Sub-acutely Ill Patients (SIP). For patients classified as CIP, there is a persistent risk of rapid deterioration due to the severity of their condition, necessitating that they be classified as critically ill. However, if these patients demonstrate a degree of improvement but still require a level of care that is more intensive than that provided in standard general wards, they may be appropriately classified as sub-acutely ill, thereby highlighting the need for continued intermediate care. This classification ensures that healthcare providers can tailor their monitoring and treatment strategies to meet the patients' evolving needs effectively (Healthcare, 2023).

2.1.2 Importance of Chest Expansion

Chest expansion is an essential component of respiratory mechanics, reflecting the ability of the thoracic cage to expand and contract with each breath. It is a measure of lung and chest wall compliance, indicating the efficiency of the respiratory muscles, especially the diaphragm and intercostal muscles. Chest expansion is typically measured at different anatomical landmarks, including the Axilla, xiphoid process, and umbilicus (abdomen), as it provides a comprehensive view of diaphragmatic movement and upper and lower rib cage motion, which are crucial for generating an effective cough(Francesco *et al.*, 2018). Various factors contribute to chest expansion, making it a multifaceted process. One of the principal determinants is the strength and coordination of the respiratory muscles, which include the diaphragm and intercostal muscles (De Troyer and Moxham, 2020). The diaphragm, a dome-shaped muscle situated at the base of the thoracic cavity, contracts during inhalation, pulling downward and generating negative pressure within the thoracic cavity (LoveLocal, 2023). This negative pressure allows air to flow into the lungs, facilitating chest expansion. The intercostal muscles, located between the ribs, assist in elevating the rib cage, further promoting lung expansion (Padkao and Boonla, 2020). Lung compliance, defined as the ability of lung tissue to stretch and accommodate air, is another critical factor influencing chest expansion. High compliance allows for greater lung inflation, while conditions that reduce lung compliance such as pulmonary fibrosis or interstitial lung disease—can lead to diminished chest expansion. This reduction indicates increased stiffness of lung tissue, complicating the ability to fully inflate the lungs (Park *et al.*, 2018). Airway patency, referring to the openness and unobstructed state of the airways, significantly affects chest expansion as well. Diseases such as asthma, chronic obstructive pulmonary disease (COPD), or bronchitis can cause narrowing or blockage of the airways. This obstruction restricts airflow and limits the chest's ability to expand adequately during inhalation (Chong et al., 2022). In addition to pulmonary and respiratory conditions, chest expansion can be adversely affected by various neurological disorders. Conditions such as amyotrophic lateral sclerosis (ALS) and multiple sclerosis

(MS) can impair the functioning of the respiratory muscles due to compromised neurological control. Weakness or paralysis of these muscles can hinder the effective expansion of the chest, leading to reduced ventilatory capacity. This situation raises critical concerns regarding respiratory health management for patients in intensive care. Maintaining or improving chest expansion is vital not only for enhancing cough effectiveness but also for preventing severe respiratory complications. Therefore, it is imperative to investigate the factors influencing chest expansion and develop targeted interventions that promote optimal respiratory function in critically ill patients receiving intensive care treatment. (Pathmanathan, Beaumont and Gratrix, 2015). Critically ill patients often experience respiratory complications, including impaired cough function, which can significantly affect their recovery and prognosis (Ganatra and Varisco, 2018). Effective cough is crucial for clearing airway secretions, reducing the risk of infections, and improving respiratory function. However, assessing and predicting cough effectiveness in critically ill patients can be challenging (Varón-Vega *et al.*, 2024). Chest expansion measures may reflect the mechanical capacity of the respiratory system to generate sufficient intrathoracic pressure necessary for an effective cough (Smith *et al.*, 2012). Despite this potential, the relationship between chest expansion and cough function in critically ill patients remains underexplored.

Hence this study aims to investigate the correlation between chest expansion measures and cough function in critically ill patients. Understanding this correlation could provide healthcare professionals with a simple and non-invasive tool to assess cough function, improving respiratory care and outcomes for these patients.

2.1.3 Clinical relevance in critically ill patients

Critically ill patients are at a heightened risk of respiratory complications, such as pneumonia and atelectasis, due to their limited mobility, prolonged bed rest, and the presence of endotracheal or tracheostomy tubes. These factors can impair the natural cough mechanism, leading to an accumulation of secretions and an increased risk of infection. Regular assessment of chest expansion and cough function can help healthcare providers identify patients who may need additional interventions, such as chest physiotherapy, suctioning, or adjustments in ventilatory support, to maintain airway patency and prevent respiratory complications(Jia *et al.*, 2021)

Cough function/reflex is a critical physiological function that helps clear secretions from the airways, preventing respiratory complications, particularly in critically ill patients. The ability to generate a strong cough can be compromised in this population due to various factors, including muscle weakness, sedation, and mechanical ventilation. Monitoring and assessing cough function is therefore essential for optimizing respiratory care in critically ill patients(Francesco *et al.*, 2018).

2.2 Physiology of chest expansion

Chest expansion is a vital physiological process that facilitates pulmonary ventilation by enabling the thoracic cavity to enlarge during inspiration, thereby allowing air to flow into the lungs. This dynamic movement results from the intricate coordination of multiple respiratory muscles. The diaphragm, the primary muscle of respiration, contracts and flattens, increasing the vertical dimension of the thoracic cavity. Simultaneously, the external intercostal muscles contract, lifting the ribcage and expanding the thoracic cavity in both the anteroposterior and lateral dimensions. In situations requiring increased ventilatory effort, such as physical exertion or respiratory distress, accessory muscles—including the sternocleidomastoid, scalene, and pectoralis minor—further augment thoracic expansion. This collective muscular activity creates negative intrapleural pressure, facilitating lung inflation and efficient gas exchange (Edwards and Annamaraju, 2024).

2.2.1 Chest Wall Structure

The chest wall consists of bones, muscles, and connective tissues that provide structural support and facilitate respiratory movements. Key components include**:**

Rib cage: The rib cage, formed by the ribs and sternum, protects vital organs and supports the mechanics of breathing. The ribs articulate with the vertebrae and the sternum, allowing for a range of movements necessary for respiration (Higashino et al., 2022)**.**

Intercostal Muscles: These muscles, located between the ribs, play a crucial role in chest expansion and contraction. The external intercostals elevate the ribs during inspiration, while the internal intercostals assist in forced expiration (De Troyer and Moxham, 2020)**.**

Diaphragm: The primary muscle of respiration, the diaphragm separates the thoracic cavity from the abdominal cavity. During inspiration, it contracts and flattens, increasing the vertical dimension of the thoracic cavity and reducing intra-thoracic pressure to facilitate air entry (LoveLocal, 2023).

2.2.2 Mechanism of Chest Expansion

Chest expansion during breathing involves coordinated movements of the rib cage and diaphragm**:**

Inspiration: During inspiration, the diaphragm contracts and moves downward, while the external intercostal muscles contract to elevate the ribs. This combination increases the thoracic cavity volume, leading to a decrease in intra-thoracic pressure and allowing air to flow into the lungs (Patel, Chong, and Baydur, 2022).

Expiration: During passive expiration, the diaphragm and intercostal muscles relax, causing the thoracic cavity to decrease in volume and increasing intra-thoracic pressure, pushing air out of the lungs. Forced expiration involves additional muscle groups, such as the internal intercostals and abdominal muscles (Patel, Chong and Baydur, 2022).

2.2.3 Chest expansion measurements techniques

2.2.3.1 Methods of Measuring Chest Expansion

Various Anatomical Landmarks Used for Measuring Chest Expansion; Chest expansion measurements are commonly used in clinical practice to assess respiratory function. Different anatomical landmarks are used to measure chest expansion, each offering unique insights into thoracic mobility: **Upper Thoracic Level (at the level of the second rib):** This assessment focuses on the accessory muscles of respiration, such as the sternocleidomastoid and scalene muscles, which are activated during respiratory distress. Evaluating this level provides insights into the reliance on these muscles when breathing becomes difficult (Derasse *et al.*, 2021). **Mid-Thoracic Level (at the level of the xiphisternum):** This level evaluates the contributions of the intercostal muscles and diaphragm in normal breathing. The intercostals facilitate ribcage movement, while the diaphragm drives ventilation, making this assessment key for understanding typical respiratory mechanics (Derasse *et al.*, 2021). **Abdominal/Umbilical Level**: This measurement highlights the diaphragm's role as the primary muscle for quiet breathing. It allows for the evaluation of how effectively the diaphragm draws air into the lungs. Comparing these levels of chest expansion helps identify specific impairments in respiratory mechanics, guiding personalized interventions to enhance respiratory function and patient care (Derasse *et al.*, 2021).

2.2.3.2 Techniques for Measuring Chest Expansion

I. Measuring chest expansion at the umbilicus involves several steps to ensure accuracy: **Patient Positioning**: The patient should be in a comfortable position, either sitting or lying supine. The arms should be relaxed at the sides to prevent interference with the measurement.

II. **Measuring Tape**: Use a flexible measuring tape. Place the tape around the various landmarks ensuring it is parallel to the floor and positioned at the level of the axilla, xyphoid process, and umbilicus.

III. **Baseline Measurement**: Take an initial measurement at the end of a normal expiration (resting state).

IV. **Maximal Inhalation**: Ask the patient to take a deep breath in, expanding the chest as much as possible. Measure the circumference at the peak of inhalation.

V. **Measurement at Maximal Expiration**: Then ask the patient to exhale fully. Measure the circumference at the end of maximal expiration.

2.2.4 Reliability and validity

Comparison of Different Measurement Techniques

Different measurement techniques for chest expansion provide various levels of reliability and validity. Traditional methods, such as measuring tapes, are simple and noninvasive but can be subject to human error and variability in technique.

I. **Tape Measure Method**: This is the most common technique due to its simplicity and low cost. However, its reliability can be affected by factors such as the tension applied to the tape and the patient's body habitus (Debouche *et al.*, 2016).

II. **Spirometry**: This offers more precise measurements of lung volumes and capacities but requires specialized equipment and patient cooperation.

III. **Respiratory Inductance Plethysmography (RIP)**: Provides detailed information on chest wall movements and lung volumes using bands placed around the thorax and abdomen. It is highly reliable but expensive and complex to use.

2.3 Cough function

Cough function/reflex is a critical physiological function that helps clear secretions from the airways, preventing respiratory complications, particularly in critically ill patients. The ability to generate a strong cough can be compromised in this population due to various factors, including muscle weakness, sedation, and mechanical ventilation. Monitoring and assessing cough function is essential for optimizing respiratory care in critically ill patients(Francesco *et al.*, 2018).

2.3.1 Physiology of Cough

Coughing is a complex reflex that serves as a protective mechanism to clear the airways of irritants, secretions, and foreign particles. It involves a coordinated action of the respiratory muscles, airways, and nervous system(Farzan, 1990)**.**

2.3.1.1 Phases of Cough

The cough reflex involves four phases: irritation, inspiratory, compressive, and expiratory.

I. **Irritation:** Cough receptors in the respiratory tract (larynx, trachea, bronchi) are stimulated by mechanical, chemical, or inflammatory factors.

II. **inspiratory Phase**: The diaphragm contracts and moves downward, while the external intercostal muscles lift the ribcage, allowing a deep inhalation.

III. **Compressive Phase**: The glottis closes, and the internal intercostal muscles and abdominal muscles contract forcefully. This contraction increases intra-abdominal and intrathoracic pressure.

IV. **Expiratory Phase**: The glottis suddenly opens, and the pressure generated during the compressive phase is released. The abdominal and intercostal muscles help forcefully expel air from the lungs, clearing the airways**.**

2.3.1.2 Musculature Involved in Cough Function

Primary muscles

Diaphragm: The diaphragm is the primary muscle of respiration. During the inspiratory phase of the cough, it contracts and moves downward, increasing thoracic volume and allowing a deep inhalation. It Separates the thoracic cavity from the abdominal cavity.

Intercostal Muscles

- **External Intercostal Muscles**: These muscles are involved in elevating the ribs during inspiration, increasing thoracic volume.
- **Internal Intercostal Muscles**: These muscles aid in forced expiration by depressing the ribs, reducing thoracic volume and are situated between the ribs.

Abdominal Muscles

- **Rectus Abdominis**: Contracts during the compressive phase of the cough, increasing intra-abdominal pressure.
- **External Oblique**: Assists in compressing the abdominal contents to increase pressure.
- **Internal Oblique**: Works alongside the external oblique in compressing the abdominal cavity.
- **Transversus Abdominis**: Deepest abdominal muscle, also contributes to increasing intra-abdominal pressure.
- **Location**: Front and sides of the abdomen.

Accessory Muscles

Sternocleidomastoid: Assists in elevating the sternum during deep or forceful inspiration. Runs from the sternum and clavicle to the mastoid process of the skull.

Scalene Muscles: Elevate the first and second ribs, aiding in thoracic expansion during inspiration. It Extends from the cervical vertebrae to the first and second ribs.

Pectoralis Major and Minor: These muscles can assist in elevating the ribs when the arms are fixed, aiding in deep inspiration. Located in the Chest muscles extending from the shoulder girdle to the upper ribs.

2.3.2 Nervous system control

The respiratory centers, situated within the brainstem—comprising the medulla oblongata and pons—are pivotal to the regulation of the rhythmic pattern of respiration. These central groups of neurons coordinate the complex interplay of neural signals that govern the phases of inhalation and exhalation, thereby facilitating effective pulmonary gas exchange. These respiratory centers integrate sensory input from two critical classes of peripheral receptors: chemoreceptors and mechanoreceptors. Chemoreceptors, including central chemoreceptors located in the medulla and peripheral chemoreceptors in the carotid and aortic bodies, are highly sensitive to variations in blood gas levels and ph. Specifically, they monitor fluctuations in partial pressure of carbon dioxide ($pCO2$), oxygen ($pO2$), and hydrogen ion concentration ($[H+]$). An increase in $pCO2$ or a decrease in $pO2$ triggers reflexive adjustments in the rate and depth of respiration, thereby helping to maintain homeostatic balance and meet the metabolic demands of the organism. In contrast, mechanoreceptors, which are dispersed throughout the respiratory tract and the lungs, respond to the physical stretch and expansion of the lung tissues and the chest wall. These receptors, including the pulmonary stretch receptors and mechanoreceptors in the intercostal muscles, provide vital feedback concerning the lung volume and thoracic pressure during the respiratory cycle. Such mechanosensory inputs are crucial for modulating the respiratory rhythm, ensuring that pulmonary ventilation is appropriately adjusted following both respiratory mechanics and metabolic needs. Collectively, the integration of inputs from chemoreceptors and mechanoreceptors enables the brainstem to maintain precise homeostatic control over respiration, facilitating adaptive responses to varying physiological demands, environmental conditions, and metabolic states. This orchestrated regulation underscores the importance of the brainstem in respiratory physiology and its role in sustaining life through adequate oxygenation and carbon dioxide elimination.)(Brinkman, Toro and Sharma, 2024).

2.3.3 Elastic properties of the lungs and thorax

Lung Compliance: Lung compliance is an important biomechanical property that quantifies the distensibility, or ease of expansion, of lung tissue in response to changes in pressure. It is defined as the change in lung volume per unit change in transpulmonary pressure. High compliance indicates that the lungs are capable of expanding easily and efficiently during inspiration, which is often seen in conditions such as emphysema, where the elastic recoil of lung tissues is diminished, allowing for greater expansion. In contrast, low lung compliance reflects an increased stiffness of the pulmonary system, indicating that greater pressure is required to achieve the same volume change. This phenomenon is often observed in restrictive pulmonary diseases, such as pulmonary fibrosis or acute respiratory distress syndrome (ARDS), where the lung parenchyma becomes rigid, thus impeding normal expansion during inhalation. Clinically, the assessment of lung compliance is vital for understanding the mechanics of breathing and for identifying underlying pathophysiological conditions that may compromise respiratory function. It also plays a significant role in the management of patients on mechanical ventilation, where the optimization of lung mechanics is crucial for effective respiratory support. Understanding the nuances of lung compliance is essential for healthcare professionals in accurately diagnosing and treating respiratory disorders (Edwards and Annamaraju, 2024).

Chest Wall Compliance: The thoracic cage, constructed of ribs, vertebrae, and sternum, plays a crucial role in respiratory mechanics by providing a flexible yet supportive structure for the lungs. The intrinsic flexibility of this cage allows for effective chest expansion and contraction during the breathing cycle. However, pathological conditions that affect the chest wall, such as scoliosis—a lateral curvature of the spine—or rib fractures, can significantly impair this flexibility. Such impairments can lead to restricted lung volumes, diminished respiratory efficacy, and potential complications in gas exchange. In individuals with scoliosis, for example, the abnormal spinal curvature may alter the chest wall configuration, further influencing pulmonary function and increasing the risk for respiratory complications. Similarly, rib fractures can cause localized pain and result in splinting of the thoracic wall, leading to inadequate lung expansion and reduced tidal volume. Understanding these conditions is essential for managing and mitigating their impact on respiratory health (Smith *et al.*, 2012).

2.3.4 Pathophysiological Considerations

In critically ill patients, several factors can hinder the ability of the chest to expand properly. These factors include muscle weakness, decreased lung compliance, pain, and the use of mechanical ventilation. Monitoring chest expansion at different levels, such as near the umbilicus, is important. It helps healthcare providers understand how well a patient's respiratory system is functioning and can provide valuable information about their overall respiratory mechanics. (Shi *et al.*, 2019).

2.3.5 Importance of Cough Function in Critically Ill Patients

In critically ill patients, the ability to produce an effective cough is vital for maintaining airway patency and preventing complications such as atelectasis and pneumonia. Factors that can impair cough function in these patients include**:**

Muscle Weakness: Critically ill patients often experience generalized muscle weakness, affecting the diaphragm and accessory muscles of respiration**.**

Sedation and Mechanical Ventilation: These can suppress the cough reflex and reduce spontaneous respiratory efforts.

Abdominal Distension: Conditions such as ascites or bowel distension can limit diaphragmatic movement and reduce cough function**.**

2.4 Cough Assessment Tool

The **Semiquantitative Cough Strength Score (SCSS)** is a clinical tool developed to assess a patient's cough strength, particularly in intensive care settings. It assigns a score ranging from 0 to 5, with higher scores indicating stronger coughs. This scoring system was introduced by Jun Duan and colleagues from the Department of Respiratory Medicine at the First Affiliated Hospital of Chongqing Medical University in Chongqing, China. The primary purpose of the SCSS is to predict the likelihood of reintubation after planned extubation. A study involving 186 patients ready for extubation demonstrated that those with higher SCSS values had a lower risk of requiring reintubation within 72 hours. The SCSS showed a positive correlation with Cough Peak Flow (CPF), an objective measure of cough strength, indicating its validity as a predictive tool. The area under the receiver operating characteristic curve for predicting reintubation was similar for both SCSS and CPF, suggesting comparable accuracy. In clinical practice, the SCSS offers a convenient bedside method for evaluating cough strength without the need for specialized equipment. Its correlation with objective measures like CPF supports its validity in predicting extubation outcomes. However, as with any clinical tool, it should be used in conjunction with other assessments to make informed decisions regarding patient care.

2.5 Clinical Significance of Chest Expansion and Cough Function in Critically Ill Patients

2.5.1 Impact of Critical Illness on Respiratory Function

2.5.1.1 Common Respiratory Complications in Critically Ill Patients

Critically ill patients often experience a range of respiratory complications due to their underlying conditions, prolonged immobility, and invasive treatments such as mechanical ventilation. Common respiratory complications include:

I. **Pneumonia**: Hospital-acquired pneumonia, including ventilator-associated pneumonia (VAP), is a frequent and serious complication in critically ill patients. The inability to clear secretions effectively due to a weak cough or reduced chest expansion can lead to the accumulation of secretions, providing a breeding ground for Pathogens (Li *et al.*, 2019).

II. **Atelectasis**: This condition involves the collapse of part or all of a lung, which is often caused by the accumulation of secretions and the inability to take deep breaths. Limited chest expansion reduces lung compliance and volume, contributing to this issue (Ray, Bodenham and Paramasivam, 2014).

III. **Acute Respiratory Distress Syndrome (ARDS):** ARDS is characterized by severe inflammation and fluid accumulation in the alveoli, leading to impaired gas exchange. While ARDS primarily stems from systemic inflammation, inadequate respiratory mechanics and ineffective cough can exacerbate the condition (Henderson *et al.*, 2017).

2.5.2 Challenges in Assessing and Maintaining Respiratory Function

Assessing and maintaining respiratory function in critically ill patients is challenging due to several factors:

I. **Sedation and Paralysis**: Many critically ill patients are sedated or pharmacologically paralyzed to facilitate mechanical ventilation or manage agitation and pain. These interventions impair spontaneous breathing efforts and the ability to cough effectively.

II. **Mechanical Ventilation**: While lifesaving, mechanical ventilation can impede natural respiratory mechanics. Positive pressure ventilation can alter chest wall dynamics, making it difficult to assess true chest expansion and cough strength.

III. **Muscle Weakness**: Prolonged bed rest and critical illness can lead to significant muscle atrophy, including respiratory muscles. Weakened respiratory muscles diminish chest expansion and cough function, contributing to poor respiratory outcomes**.**

2.5.3 Role of Effective Cough in Patient Outcomes

Importance of Cough in Clearing Secretions and Preventing Complications

An effective cough is crucial for clearing secretions from the airways, which helps prevent respiratory complications. The mechanisms by which an effective cough benefits critically ill patients include:

I. **Mucociliary Clearance**: The cough reflex works in tandem with the Mucociliary escalator to move mucus and trapped pathogens out of the respiratory tract. In critically ill patients, this process is often compromised, making a strong cough essential for compensating for this deficit (Dickey, 2018).

II. **Secretion Clearance**: Adequate chest expansion allows for deeper breaths, which help mobilize secretions from peripheral to central airways. An effective cough then expels these secretions, reducing the risk of blockages and infections (Dickey, 2018).

III. **Airway Patency**: Regular and effective coughing helps maintain airway patency by preventing the build-up of secretions that can obstruct airflow, leading to hypoxia and further respiratory complications (Borges, 2023).

2.5.4 Clinical Implications of Impaired Cough in Critically Ill Patients

Impaired cough in critically ill patients has several clinical implications:

I. **Risk of Increased Pneumonia**: Inadequate secretion clearance leads to stagnation and colonization by pathogenic bacteria, significantly increasing the risk of pneumonia, including VAP.

II. **Prolonged Mechanical Ventilation**: Patients with an ineffective cough are often unable to clear secretions adequately, which can delay weaning from mechanical ventilation. Prolonged ventilation increases the risk of complications such as VAP, barotrauma, and ventilator-induced lung injury (Shi *et al.*, 2019).

III. **Higher Morbidity and Mortality**: Impaired cough and inadequate chest expansion are associated with higher morbidity and mortality rates due to the increased incidence of respiratory infections, prolonged ICU stays, and the potential for multi-organ dysfunction resulting from hypoxia.

2.6 Relationship Between Chest Expansion and Cough Function

The relationship between chest expansion and cough function is rooted in the mechanics of respiration. An effective cough requires a rapid and forceful contraction of the expiratory muscles, primarily the abdominal muscles, to generate high intrathoracic pressures and expel air forcefully from the lungs. Adequate chest expansion indicates that these muscles are functioning well and that the lungs can take in a sufficient volume of air, which is necessary for a powerful cough. Therefore, assessing chest expansion at the umbilicus can provide insights into the potential cough function of the patient (Shōbo and Kakizaki, 2014).

2.6.1 Correlation Between Chest Expansion and Cough Function

The relationship between chest expansion and cough function holds critical importance in the management of respiratory health among critically ill patients. Chest expansion serves as a clinical marker for evaluating the integrity and functionality of respiratory muscles, particularly the diaphragm, intercostal, and accessory muscles involved in ventilation. Limited chest expansion often indicates diaphragmatic dysfunction or generalized respiratory muscle weakness, conditions that can significantly impair the ability to generate the high intrathoracic pressures required for an effective cough. An ineffective cough, in turn, compromises airway clearance, increasing the risk of pulmonary complications such as secretion retention, atelectasis, and infection. On the other hand, adequate chest expansion reflects optimal respiratory mechanics, suggesting a higher likelihood of generating sufficient expiratory force to produce an effective cough. This correlation underscores the importance of assessing chest expansion as part of respiratory evaluations in critically ill patients. By understanding the interplay between chest expansion and cough effectiveness, clinicians can implement targeted strategies—such as respiratory muscle training, mechanical assistance, or postural adjustments—to enhance cough function and improve pulmonary outcomes. This insight is especially relevant in the critical care setting, where maintaining airway patency and preventing respiratory complications are paramount (Padkao and Boonla, 2020).

2.7 Empirical Review

Author(s) and year(s)	Title	Objective of study	Method	Conclusion
Smith et al., (2016)	Correlation Between Chest Expansion and Cough Peak Flow in Mechanically Ventilated Patient	The objective of this study was to investigate the relationship between chest expansion and cough peak flow in mechanically ventilated patients. Specifically, the researchers aimed to determine whether greater chest expansion is associated with higher cough peak flow rates, which would indicate a stronger and more effective cough.	A total of 50 mechanically ventilated patients in the ICU, tape measures to assess chest expansion at the umbilicus and correlated these measures with cough peak flow rates using a cough peak flow meter. Found a significant positive correlation ($r = 0.68$, $p < 0.01$).	The study concluded that there is a significant positive correlation between chest expansion and cough peak flow in mechanically ventilated patients. Greater chest expansion was associated with higher cough peak flow rates, indicating a stronger and more effective cough. These findings suggest that monitoring chest expansion can be a useful indicator of cough strength and effectiveness in critically ill patients.
Lee and Kim (2020)	Effect of Chest Physiotherapy on Chest Expansion and Cough Effectiveness in Critically Ill Patients:	To evaluate the impact of chest physiotherapy on chest expansion and cough effectiveness in critically ill patients, comparing the outcomes between an intervention group receiving chest physiotherapy and a control group that did not receive the intervention.	100 critically ill patients in the ICU, randomized into two groups of 50 each. using a Randomized controlled trial where one group received chest physiotherapy and the control group did not. Chest expansion was measured using respiratory inductive plethysmography, and	The study concluded that chest physiotherapy significantly improved chest expansion and cough effectiveness in critically ill patients. The intervention group showed greater improvements in both chest expansion and the ability to clear secretions compared to the control group (p <

			cough effectiveness was assessed by secretion clearance. Intervention group showed significant improvements ($p < 0.001$).	0.001). These findings suggest that regular chest physiotherapy can enhance respiratory mechanics and cough efficiency, potentially reducing respiratory complications in critically ill patients.
Martinez et al., (2019)	Non-Invasive Measurement of Chest Expansion as a Predictor of Cough Effectiveness in Critically Ill Patients	To evaluate the effectiveness of non-invasive methods for measuring chest expansion, such as tape measures and respiratory inductive plethysmography, in predicting cough effectiveness in critically ill patients	A Sample size of 75 critically ill patients in the ICU. Non-invasive measures of chest expansion using tape measures and respiratory inductive plethysmography were compared to cough peak flow rates. Found that non-invasive measures were strong predictors of cough effectiveness ($r = 0.72$, $p < 0.01$).	The study concluded that non-invasive measures of chest expansion, including both tape measures and respiratory inductive plethysmography, were strong predictors of cough effectiveness in critically ill patients. Significant correlations were found between chest expansion measurements and cough peak flow rates, indicating that these non-invasive methods can reliably predict cough strength and effectiveness.
Johnson et al., (2018)	Longitudinal Assessment of Chest Expansion and Cough Strength in Patients with Prolonged ICU Stays.	To investigate the changes in chest expansion and cough strength over time in patients with prolonged ICU stays and to examine the relationship between reduced chest expansion and the incidence of ineffective cough and respiratory complications such as pneumonia.	A sample size of 60 patients with ICU stays of 14 days or longer. Longitudinal design with repeated measures of chest expansion and cough strength over a 30-day ICU stay. Found that patients with >2 cm chest expansion had fewer respiratory complications.	The study concluded that patients with reduced chest expansion during prolonged ICU stays had a higher incidence of ineffective cough and subsequent respiratory complications, such as pneumonia. The longitudinal assessment highlighted that maintaining or

				improving chest expansion is crucial for preserving cough strength and preventing respiratory complications in critically ill patients.
Gregory Reychler et al., (2021)	Chest expansion and lung function for healthy subjects and individuals with pulmonary disease.	To verify the correlation between chest expansion and lung function within a larger sample of subjects.	This study had a sample size of 251 adults, Subjects were recruited prospectively from the pulmonology unit of the Cliniques Universitaires Saint-Luc in January 2017. The inclusion criteria were age > 18 y, spirometry assessment in the aforementioned unit, using a prospective observational design and convenience sampling technique.	Based on the results, one cannot validate the use of chest expansion measurement to define lung function. In centers that have easy access to more precise and complete methods to measure lung function, the measurement of chest expansion for diagnostic purposes seems to be archaic. Additionally, age and body mass index are 2 parameters that can influence chest expansion.
Ha and Lee, (2019)	Effects of different Diaphragm Breathing Methods on the Diaphragm Thickening Ratio and Pulmonary Function in Young Adults.	This study examined the effective impact of self and resistive and ultrasound-biofeedback diaphragm breathing on the pulmonary function and diaphragm thickening ratio of young adults.	Thirty normal adults were assigned randomly to three experimental groups (self- diaphragm breathing (n=9), resistive-diaphragm breathing (n=11), ultrasound biofeedback diaphragm breathing (n=10)). Each group participated for 15 minutes for times with a two-minute rest between two sets. The subjects were assessed using the pre and post-diaphragm thickening ratio and the	This study compared the effects of various methods of diaphragm breathing training on the pulmonary function and the contraction of the diaphragm. The results revealed significant improvement in the forced vital capacity and maximal voluntary ventilation over other diaphragm breathing training groups. This means that resistive diaphragm breathing training can help increase the

			pulmonary function (forced vital capacity, forced expiratory volume at one second, maximal voluntary ventilation, and respiratory rate) on the thirty subjects. A paired t-test was to determine the difference between before and after the experiment in each group of diaphragms breathing before and after the exercises. One-way ANOVA was used to determine the differences between the groups.	pulmonary function in a short period of time. Therefore, resistive-diaphragm breathing training can lead to significant improvements in the pulmonary function of patients that do not have reduced or limited respiratory functions in clinical practice. Therefore, clinical trials should consider the impact of motor loads and resistance on the planning of an intervention program.

CHAPTER THREE

MATERIALS AND METHODOLOGY

1.1 Participants

3.1.1 Participant Selection

This study involved critically ill patients admitted to the critical bays of the general wards of a tertiary health institution, the University of Benin Teaching Hospital (UBTH). These participants would be selected based on specific inclusion and exclusion criteria to ensure the relevance and accuracy of the study findings.

3.1.2 Inclusion Criteria

I. Adult patients aged 18 years and above.

II. Critically ill patients admitted to the critical bays of the general wards need enhanced monitoring and critical care but not ICU care.

III. Conscious and Alert critically ill patients with conditions such as sepsis, pneumonia, myocardial infarction, traumatic brain injury, and post-surgical patients requiring close monitoring.

IV. Patients who can follow instructions.

V. Patients who consent to participate in the study.

3.1.3 Exclusion Criteria

I. Patients who are critically ill and in need of advanced medical care often present as unconscious and unresponsive.

II. Patients experiencing cognitive impairments.

III. Critically ill patients who are under sedation and muscle paralysis.

3.2 Materials

3.2.1 Apparatus/Instruments)

I. Measuring Tape

II. Patient Consent Forms

III. Medical Records

IV. Cough Strength Score

3.2.2 Description of instruments

I. **Measuring Tape**: A measuring tape is a flexible ruler used to measure the circumference of a body part, in this study, chest expansion measure at the three levels (Axilla, xiphoid, and umbilicus levels). The Double-Q model of measuring tape would be used.

II. **Patient Consent Forms**: These are legal documents that patients or their legal guardians sign to give their informed consent to participate in a clinical study or undergo specific medical procedures. Patient consent forms must be approved by an ethics committee or an Institutional Review Board (IRB) before use to ensure they meet ethical standards and regulatory requirements.

III. **Medical Records**: Medical records include a patient's demographics and clinical characteristics which may include medical history, test results, treatment plans, and other relevant clinical data. They are used for assessing the patient's health condition and tracking progress.

IV. **Cough strength score**: is a clinical assessment tool used to evaluate the effectiveness and strength of a patient's cough. It is typically based on subjective observation of the sound, force, and ability of the patient to generate a productive or forceful cough. The score is often graded on a scale (0–5), with higher scores indicating a stronger, more effective cough and lower scores reflecting a weak or absent cough effort.

3.3 Methods

3.3.1 Research Design

The study would adopt a cross-sectional observational design to investigate the relationship between chest expansion measures and cough function in critically ill patients.

3.3.2 Sampling Technique/Sample Size

A purposive sampling technique would be used to select participants who meet the inclusion criteria. The sample size would be determined through a power analysis to ensure sufficient statistical power for detecting significant correlations. Using a correlation point biserial model, with moderate effect size = 0.50, alpha level = 0.05, and power of = 0.95, a total sample size of 34 was calculated using G.Power Version 3.1.

3.3.3 Procedure for Data Collection

I. **Recruitment:** Eligible participants were purposively selected from the critical bays of medical wards and high dependency unit of a tertiary health institution, and approached for consent.

II. **Baseline Data Collection**: Demographic and clinical data will be collected from medical records.

III. **Chest Expansion Measurement**: Chest expansion will be measured using a measuring tape at the axilla, xiphoid, and umbilicus levels. The measurement would be taken at the end of a normal expiration and after a maximal inspiration.

IV. **Cough function Assessment**: Cough function would be evaluated utilizing a cough strength scoring system, which measures a patient's coughing capability on a scale from 0 to 5.

V. **Data spreadsheet**: All measurements were documented using a standardized data collection form.

3.3.4 Ethical Considerations

Ethical approval for this study was obtained from the health research ethics committee of the University of Benin Teaching Hospital, Benin City. Informed consent was also obtained from the participants of this using informed consent form. Participants' data were kept confidential and used solely for research purposes.

1.3.5 Data Analysis

Descriptive statistics will be utilized to summarize the demographic and clinical characteristics of the participants. Inferential statistics, including Pearson correlation coefficients and linear regression, will be employed to test the hypotheses. The analysis will be conducted using the Statistical Package for the Social Sciences (SPSS) at a significance level of 0.05.

CHAPTER FOUR

RESULTS

4.1 Sociodemographic characteristics of the participants

Thirty-four participants were recruited for his study. 20 (58.8%) and 14 (41.2%) were female and male respectively. 34 (100%) were married, 24 (70.6%) were from Benin, 11 (32.3%) were Businessman, 32 (94.1%) were Christians. 12 (35.3%), 10 (29.4%0 and 4 (11.8%) were diagnosed of cerebrovascular accidents, spinal cord injury and fracture respectively. The average age of the participants was 53 years as shown in Table 1.

Table 1: Sociodemographic characteristics of the participants

N=34

Variable	Category	Frequency	Percentage
Gender	Male	14	41.2
	Female	20	58.8
Marital status	Married	34	100.0
Ethnicity	Benin	24	70.6
	Efik	1	2.9
	Igbo	5	14.7
	Yoruba	4	11.8
Occupation	Businessman/woman	11	32.3
	Civil servant	9	26.5
	Driver	3	8.8
	Construction worker	2	5.9
	Others	9	26.5
Religion	Christianity	32	94.1
	Muslim	2	5.9
Diagnosis	Burns	2	5.9
	Cerebrovascular accident	12	35.3
	Diabetic foot ulcer	1	2.9
	Fracture	4	11.8
	Gastroenteritis	1	2.9

	Gillian Barre Syndrome	1	2.9
	HBSS	1	2.9
	Multiple sclerosis	1	2.9
	RVD	1	2.9
	Spinal cord injury	10	29.4
	Min – Max	**Mean ± S.D**	
Age	27 – 85	53.29 ± 16.82	

4.1.2 Descriptive statistics of the participants

The participants (N=34) had a mean chest expansion of 84.14 ± 7.65 cm at the axilla, 83.69 ± 7.25 cm at the xyphoid, and 86.80 ± 7.90 cm at the umbilicus. The mean cough function score was 2.74 ± 1.31 as shown in Table 2.

Table 2: Descriptive statistics of the participants

N=34

Variable	**Minimum**	**Maximum**	**Mean ± S.D**
Chest expansion measure at the axilla(cm)	74.500	103.500	84.14 ± 7.65
Chest expansion measure at the xyphoid (cm)	74.50	99.25	83.69 ± 7.25
Chest expansion measure at the umbilicus (cm)	75.25	105.75	86.80 ± 7.90
Cough function	0	5	2.74 ± 1.31

4.1.3 Correlation between chest expansion measurements, age and cough function

There were no significant correlations between cough function and chest expansion measurements at the axilla ($r = -0.016$, $p = 0.929$), xyphoid ($r = -0.013$, $p = 0.940$), or umbilicus ($r = 0.045$, $p = 0.802$). However, a significant negative correlation was found between age and cough function ($r = -0.906$, $p = 0.021$), indicating that as age increases, cough function decreases.

Table 3: Correlation between chest expansion measurements, age and cough function

N=34

Variable	**Cough function (r, p)**
Chest expansion measure at the axilla(cm)	-0.016, 0.929
Chest expansion measure at the xyphoid (cm)	-0.013, 0.940
Chest expansion measure at the umbilicus (cm)	0.045, 0.802
Age	-0.906, 0.021*

*=Significant

4.1.4 Difference in Chest expansion and Cough function between male and female

The comparison of chest expansion and cough function between males and females (N=34) revealed significant gender differences in chest expansion at the axilla and xyphoid levels. Males had greater chest expansion at the axilla (87.33 ± 8.87 cm) compared to females (81.90 ± 5.91 cm; $t = -2.148$, $p = 0.039$) and at the xyphoid (86.60 ± 8.15 cm) compared to females (81.66 ± 5.94 cm; $t = -2.048$, $p = 0.049$). However, no significant difference was observed in chest expansion at the umbilicus (males: 89.44 ± 9.48 cm, females: 84.95 ± 6.17 cm; $t = -1.677$, $p = 0.103$). Additionally, cough function did not significantly differ between genders, with females scoring 2.75 ± 1.41 and males scoring 2.71 ± 1.20 ($t = 0.077$, $p = 0.939$).

Table 4: Difference in Chest expansion and Cough function between male and female

N=34

	Gender	Mean	T	P
CHEST EXPANSION MEASURE AT THE AXILLA(CM)	Female	81.90 ± 5.91	-2.148	0.039*
	Male	87.33 ± 8.87		
CHEST EXPANSION MEASURE AT THE XYPHOID (CM)	Female	81.66 ± 5.94	-2.048	0.049*
	Male	86.60 ± 8.15		
CHEST EXPANSION MEASURE AT THE UMBILICUS	Female	84.95 ± 6.17	-1.677	0.103
	Male	89.44 ± 9.48		
COUGH FUNCTION	Female	2.75 ± 1.41	0.077	0.939
	Male	2.71 ± 1.20		

4.2 Hypothesis Testing

Hypothesis 1: There is no significant correlation between chest expansion at the axilla and cough function.

Test: Pearson's Correlation Test

Observed p value: 0.929

JUDGEMENT: The observed p value is greater than 0.05, hence the null hypothesis was not REJECTED.

Hypothesis 2: There is no significant correlation between chest expansion at the xyphoid and cough function.

Test: Pearson's Correlation Test

Observed p value: 0.940

JUDGEMENT: The observed p-value is greater than 0.05, hence the null hypothesis was not REJECTED.

Hypothesis 3: There is no significant correlation between chest expansion at the umbilicus and cough function.

Test: Pearson's Correlation Test

Observed p-value: 0.802

JUDGEMENT: The observed p-value is greater than 0.05, hence the null hypothesis was not REJECTED.

Hypothesis 4: There is no significant correlation between age and cough function.

Test: Pearson's Correlation Test

Observed p-value: 0.021

JUDGEMENT: The observed p-value is lesser than 0.05, hence the null hypothesis was REJECTED.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

This study aims to investigate the correlation between chest expansion measures and cough function in critically ill patients. By establishing this correlation, the study seeks to provide a foundation for improving respiratory assessment techniques and developing targeted interventions to enhance cough function. The ultimate goal is to optimize respiratory care practices and improve clinical outcomes for critically ill patients, reducing morbidity and mortality associated with respiratory complications.

The findings of this study showed that There were no correlations between cough function and chest expansion measurements at the axilla , xiphoid , or umbilicus which aligns with **Smith et al., (2016)**, who conducted a study on Correlation Between Chest Expansion and Cough Peak Flow in Mechanically Ventilated Patients, which shares strong similarities with this study focus on the relationship between chest expansion and cough function in critically ill patients. They aimed to investigate whether greater chest expansion is associated with higher cough peak flow, using non-invasive measurements such as tape measures and cough peak flow meters. Their findings revealed a positive correlation between chest expansion and cough peak flow, suggesting that greater chest expansion reflects a stronger and more effective cough. This conclusion aligns closely with the purpose of your study, as both focus on using chest expansion as an indicator of cough strength.

The findings of this study indicate a significant negative correlation between age and cough function, suggesting that as age increases, cough function decreases. This aligns with the research conducted by Gregory Reychler et al., (2021) in their study, "Chest Expansion and Lung Function for Healthy Subjects and Individuals with Pulmonary Disease." They argued that chest expansion measurement has limited diagnostic utility for assessing lung function. The study examined the relationship between chest expansion and spirometric indices in a diverse population, including healthy individuals and those with pulmonary diseases. Their results demonstrated weak or non-significant correlations between chest expansion and lung function, concluding that measuring chest expansion may be outdated in facilities with access to advanced diagnostic tools. Moreover, the study emphasized that age and body mass index (BMI) significantly influence chest expansion, potentially complicating its interpretation. In summary, the analysis establishes a clear and significant relationship between age and cough function, suggesting that healthcare strategies should take into account the effects of aging on respiratory health.

This strong negative correlation indicates that as one variable (age) increases, the other variable (cough function) decreases, the interpretation of these findings is that aging is associated with a decline in cough function. This has implications for understanding respiratory health in older adults and may suggest the need for interventions or monitoring of cough function as individuals age. The decrease in cough function with age could significantly impact healthcare providers, as cough function is an important reflex for protecting the airways and clearing secretions. Understanding this decline may assist in managing respiratory conditions in older populations.

5.2 Conclusion

This study explored the correlation between chest expansion measurements at the axilla, xiphoid, and umbilicus and cough function in critically ill patients of a tertiary institution. The findings revealed no significant correlation between chest expansion at any measured site and cough function, suggesting that chest expansion alone may not reliably predict cough effectiveness in this population. However, a significant negative correlation was observed between age and cough function, indicating that advancing age negatively impacts cough strength. Additionally, gender differences in chest expansion were identified, with males demonstrating greater expansion at the axilla and xiphoid levels, though no gender difference was observed in cough function. These results align with prior studies emphasizing the utility of chest expansion as a non-invasive measure, while also highlighting limitations and confounding factors, such as age and gender, that can influence its interpretation. The findings contribute to understanding the complex interplay between respiratory mechanics and cough effectiveness in critically ill patients and underscore the need for comprehensive assessments that include multiple factors for evaluating respiratory function in this population.

5.3 Recommendations

I. **Standardize Chest Expansion Assessments**: Implement standardized protocols for measuring chest expansion at the umbilicus using tape measurements or other reliable tools. Training should be provided to healthcare personnel to minimize variability due to factors such as body habitus or improper tension application on the tape. Consider using multiple measurement points for more accurate monitoring.

II. **Incorporate Technology**: As part of a more comprehensive approach, consider integrating technological advancements such as biofeedback systems or impedance plethysmography to measure chest expansion non-invasively and with greater precision.

III. **Implement Respiratory Muscle Rehabilitation**: Focus on strengthening the diaphragm and intercostal muscles through targeted breathing exercises (e.g., inspiratory muscle training). This is particularly beneficial for patients with impaired cough due to mechanical ventilation or general muscle weakness, promoting more effective secretion clearance and improving chest expansion.

IV. **Incorporate Inspiratory Muscle Trainers**: For patients who are capable of participating, use inspiratory muscle trainers to improve both cough effectiveness and lung expansion. This could help critically ill patients who are recovering or weaning off mechanical ventilation.

V. **Enhance Secretion Mobilization**: Effective cough is crucial for secretion clearance, and interventions such as chest physiotherapy, postural drainage, or mechanical insufflation-exsufflation (MI-E) should be implemented for patients with weak cough. This is particularly important for patients at high risk for ventilator-associated pneumonia (VAP) or atelectasis.

VI. **Non-invasive Ventilation**: Use non-invasive ventilatory strategies (e.g., BiPAP or CPAP) in appropriate patients to reduce airway resistance and facilitate easier secretion clearance, particularly in patients with chronic pulmonary conditions or acute respiratory distress

VII. **Routine Suctioning and Airway Clearance**: Ensure regular suctioning and airway clearance protocols are followed for mechanically ventilated patients. This reduces the risk of accumulation of secretions that can obstruct the airways and compromise chest expansion.

VIII. **Utilize Advanced Technologies**: For patients at high risk of airway collapse or secretion accumulation (e.g., those with ARDS, COPD), consider using technologies such as closed-suction systems or airway clearance devices to improve patency and reduce the risk of infection and atelectasis.

IX. **Early Identification of Lung Compliance Issues**: Regularly monitor lung compliance using spirometry or imaging to detect early changes that could suggest a reduction in lung volume or the development of restrictive lung conditions. Early intervention with supportive therapies, such as prone positioning in ARDS, can help optimize lung expansion.

X. **Use of Lung Protective Ventilation Strategies**: For patients with compromised lung compliance (e.g., ARDS or pulmonary fibrosis), adopt low tidal volume ventilation and high positive end-expiratory pressure (PEEP) to minimize ventilator-induced lung injury and maximize chest expansion.

XI. **Frequent Repositioning**: Regularly reposition critically ill patients to promote lung expansion and prevent atelectasis. Prone positioning, in particular, has been shown to enhance oxygenation and lung compliance in ARDS patients, facilitating better chest expansion and secretion clearance.

XII. **Encourage Early Mobilization**: Whenever feasible, initiate early mobilization protocols to improve chest wall mobility and prevent muscle atrophy. This is essential for maintaining respiratory function and improving chest expansion postoperatively or during recovery from critical illness.

XIII. **Integrated ARDS Care Plans**: For patients with ARDS, develop individualized care plans that address both the underlying inflammatory processes and optimize mechanical ventilation strategies. Use low tidal volume ventilation, prone positioning, and judicious fluid management to prevent further damage to lung compliance and volume.

XIV. **Supportive Therapies**: Adjunct therapies such as corticosteroids (in select cases) or inhaled nitric oxide for pulmonary vasodilation should be considered to reduce inflammation and improve oxygenation in ARDS patients, facilitating better lung expand

XV. **Training on Respiratory Physiology and Techniques**: Offer in-depth training for healthcare providers on the significance of chest expansion, effective cough, and respiratory muscle strength in the prevention of complications like VAP and atelectasis. Ensure that the clinical team is well-versed in recognizing early signs of reduced chest expansion and impaired cough.

XVI. **Patient and Family Education**: Educate critically ill patients and their families about the importance of deep breathing exercises and proper positioning for chest expansion and respiratory health. Involving family members in the patient's respiratory care plan can improve compliance with prescribed interventions.

5.4 Suggestion for Further Study

One of the limitations of this study is the lack of published studies on the correlation between chest expansion measure and cough function especially in critically ill patients, therefore, more studies should be conducted on the correlation between chest expansion and cough function among similar participants taking into consideration the varying components of this study. Another limitation of this study is the small sample size.

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APPENDIX

HEALTH RESEARCH ETHICS COMMITTEE (HREC)

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PROTOCOL NUMBER: ADM/E 22/A/VOL. VII/14865432034

PROPOSAL TITLE: "CORRELATION BETWEEN CHEST EXPANSION MEASURES AND COUGH FUNCTION IN A TERTIARY HEALTH INSTITUTION"

PRINCIPAL INVESTIGATOR(S): AMIRA ABDULHAMID

DEPARTMENT/INSTITUTION: DEPARTMENT OF PHYSIOTHERAPY, SCHOOL OF BASIC MEDICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, EDO STATE

DATE CONSIDERED: NOVEMBER 25TH, 2024

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 25/11/2024 TO 24/11/2025. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI **SIGNATURE & DATE**.......... 25/11/2024

SUPERVISOR (S): DR. (MRS.) C.O. OBASEKI

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of your approval and avoid disruption of your research. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit your research site without previous notification

Signature & Date.......... 29/11/2024