THE OUTCOMES OF ADULT PATIENTS RECOVERING FROM MAJOR THORACIC TRAUMA WHO PARTICIPATED IN A PROGRAMME OF MYOFASCIAL RELEASE AND ACTIVE EXERCISE THERAPY

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DECLARATION

I, Kyra Lee Blewitt, declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Kyra Lee Blewitt
30 September 2024

DEDICATION

Dedicated to my Husband, Daughter, Family, Colleagues and Patients

ABSTRACT

Background and Purpose: Thoracic trauma can result in decreased respiratory function and chronic pain which affects a person's quality of life (QOL). Patients who have suffered thoracic trauma often require prolonged hospital care. Pain and immobilisation have deconditioning effects on patients such as loss of muscle strength and respiratory complications. There is a lack of research into how a post discharge physiotherapy intervention impacts chronic pain and QOL in South African patients recovering from thoracic trauma. The effect of manual myofascial release techniques applied to the intercostal muscles and diaphragm on pain levels, pulmonary function, exercise capacity, and QOL outcomes for those recovering from thoracic trauma are unknown. Active exercises of the thoracic cage help to improve the thoracic range of motion in patients recovering from thoracic trauma. The proposed interventions of myofascial release and active exercises and its effects on patient outcomes has not been investigated previously. The purpose of this study was to determine the outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial release and active exercise therapy after hospital discharge.

Methods: A prospective, longitudinal, quasi-experimental repeated measures design with a consecutive sampling method was conducted on patients with thoracic trauma after discharge from the trauma ward at a private hospital in Johannesburg. Outcomes assessed prior to hospital discharge included the Euroqol 5D (EQ-5D) (pre-injury status and pre-discharge status) and the Brief Pain Index (BPI). Physiotherapy intervention commenced four weeks post discharge and consisted of heat therapy, myofascial release of the intercostal muscles and diaphragm, active cycle of breathing technique, incentive spirometry, and active thoracic cage range of motion (ROM) exercises. Participants received these interventions at four, eight and 12 weeks after discharge. Outcomes assessed at four weeks and 12 weeks after discharge included EQ-5D, BPI, International Physical Activity Questionnaire (IPAQ), Maximal Inspiratory Pressure (MIP), Peak Expiratory Flow Rate (PEFR), handgrip strength, and active thoracic ROM. At six months post discharge a telephonic follow up was made where the EQ-5D, BPI and IPAQ were reassessed. The Statistical Programming for the Social Sciences Statistics Version 23 software package was used for data analysis. Continuous data were summarised as means and standard deviations and categorical data were summarised as numbers and percentages. Paired samples t-tests were used to assess changes in continuous data over time. Level of significance was set as $p<0.05$.

Results: A total of 35 participants agreed to take part in this study and were assessed prior to hospital discharge. Of these participants, 27 (77.1%) were male and 8 (22.9%) were female. The mean age of participants was 49.3 (±15.4; range 24-89) years. Only 12 participants

completed the study. Results obtained from the BPI showed that changes in worst pain, least pain, average pain and current pain experienced by participants were all statistically significant at one-to-three month and one-to-six-month intervals ($p<0.05$, respectively). The BPI assessed pain with general activity, normal work, sleep, and enjoyment of life which all showed statistically significant changes from one to three months and one to six months ($p<0.05$, respectively). The BPI assessment of mood and walking ability showed statistically significant changes at one to six months post discharge from hospital ($p<0.05$). The mean change in pain experienced as reported with the EQ-5D visual analogue scale (VAS) from one month to six months was statistically significant ($p=0.023$). The changes observed in thoracic rotation ROM to the left and right sides from one month to three months were statistically significant ($p=0.001$ (left) and $p=0.004$ (right), respectively). Changes observed in MIP and PEFR were statistically significant from one month to three months with p-values of 0.004 and <0.001 respectively. The changes in handgrip strength using a handheld dynamometer from one month to six months was statistically significant with $p<0.001$ for both the right and left hands. Results obtained for physical activity showed that at the six month follow up 83.3% (n=10) of participants fell in the high activity category compared to 50% (n=6) of participants at the one month follow up. Overall, participants' QOL improved during the six months period as their scores increased in all five domains of the EQ-5D from one month post discharge until the six month follow up.

Conclusion: Patients who sustained thoracic trauma showed a significant improvement in their level of pain, pulmonary function (MIP and PEFR), physical function (thoracic ROM and handgrip strength), and QOL from one month to six months post discharge after receiving a physiotherapy program consisting of myofascial release and active exercises. These findings need validation through further clinical trials.

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LIST OF ABBREVIATIONS

ACBT	-	Active Cycle of Breathing Technique
BPI	-	Brief Pain Inventory
COPD	-	Chronic Obstructive Pulmonary Disease
EQ-5D	-	EuroQol-5 Dimension
HRQOL	-	Health Related Quality of Life
ICU	-	Intensive Care Unit
IL	-	Interleukin
IPAQ	-	International Physical Activity Questionnaire
MET min/week	-	Metabolic Equivalent of Task Minutes per Week
MIP	-	Maximal Inspiratory Pressure
PEFR	-	Peak Expiratory Flow Rate
QOL	-	Quality of Life
ROM	-	Range of Motion
SD	-	Standard Deviation
TNF-a	-	Tumour Necrosis Factor-Alpha
VAS	-	Visual Analogue Scale
VC	-	Vital Capacity

CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND

Thoracic trauma contributes to 20% to 25% of all trauma cases globally (Beshay et al., 2020). Thoracic trauma is the third most common cause of mortality due to trauma internationally with a reported mortality rate of 10% to 60% (Kahloul et al., 2020). According to Skinner et al. (2015), trauma represents a major burden of disease in South Africa with motor vehicle accidents being the leading cause of trauma (92%). The high incidence of trauma in South Africa may be due to poverty, lack of education, unemployment, alcohol and drug abuse, easy access to firearms as well as many other contributing factors (John and Matshoba 2015).

Thoracic trauma can have a major impact on the functioning of a person's lungs. Acute lung injury can result in loss of lung volume, alveolar derecruitment, decrease in positive end-expiratory pressure values, decreased lung compliance and decreased oxygenation (Cagini 2012). Intercostal muscles undergo atrophy as well as shortening with prolonged bed rest, mechanical ventilation or decreased physical activity (Doorduin et al., 2013). This decrease in muscle mass, strength and length of the intercostal muscles impacts chest wall mobility and expansion of the lungs. Decreased lung compliance and mobility also leads to a reduction in lung volume (Dogrul et al., 2020). Therefore, if the respiratory muscles are weak and shortened the ability of them to generate pressures to expand fully is compromised (El-Kady et al., 2018). In the acute phase after injury, this leads to atelectasis, hypoxia and respiratory infections which over time can result in reduced exercise tolerance and dyspnoea (El-Kady et al. 2018).

A pathology that negatively affects the lungs' ability to fully inspire and expire can result in alterations in the surrounding soft tissue. Fascial and respiratory muscle stiffness may occur in these pathologies (El-Kady et al., 2018). Myofascial release of the intercostal muscles and the diaphragm has shown significant improvement in vital capacity (VC) and diaphragm excursion in adult patients presenting with a pleural effusion. This results in a decreased risk of pulmonary complications and improved health-related quality of life (HRQOL) (El-Kady et al., 2018). Research has been done on intercostal muscle and diaphragm manual release and how it impacts the respiratory function of patients with chronic obstructive pulmonary disease (COPD).

Participants showed improved diaphragm mobility, inspiratory capacity as well as exercise endurance (Rocha et al., 2015). These participants also had immediate improvements in maximal expiratory pressure, VC and sniff nasal inspiratory capacity (Rocha et al., 2015). Increasing the VC and diaphragm excursion improves lung function and capacity (El-Kady et al., 2018). This decreases the risk of pulmonary complications and therefore improves patients' HRQOL (El-Kady et al., 2018). Nagy et al. (2022), compared an intervention of diaphragm release plus inspiratory muscle training to inspiratory muscle training alone in patients post COVID-19. The group that received the additional diaphragm release showed an improvement in inspiratory muscle strength whereas the control group showed no improvement (Nagy et al., 2022). Therefore, research has shown that an intervention of myofascial release of the intercostal muscles and the diaphragm can improve a person's overall HRQOL in patients with a pleural effusion, chronic obstructive pulmonary disease, and post COVID-19. Further research needs to be done to establish whether this intervention will impact a patient's HRQOL after sustaining thoracic trauma.

Van Aswegen et al. (2011) researched the HRQOL of survivors of penetrating trunk trauma in Johannesburg. They concluded that survivors of penetrating trunk trauma experienced physical impairment in HRQOL up to six months post discharge from hospital. Patients recovering from critical illness have a decreased ability to function due to muscle atrophy (Hofhuis et al., 2009; Schneiderman et al., 2013; Baker et al., 2021). This results in decreased HRQOL after hospital discharge. Treatment of critically ill patients was previously focused on survival; however, more attention is now focused on the HRQOL of these patients (Hofhuis et al., 2009). Therefore, muscle weakness and poor HRQOL is evident in patients recovering from critical illness. Research should focus on whether a post discharge physiotherapy intervention program decreases the incidence of poor HRQOL.

Chronic pain is defined as "pain that lasts more than three to six months, or beyond the point of tissue healing" (Spine Health, 2021, p.2). Chronic pain contributes significantly to poor HRQOL and workplace absenteeism (Gordy et al., 2014). Nineteen percent of patients, who sustained rib fractures, make unscheduled visits to the hospital requesting analgesia (Shelat et al., 2012). Furthermore, a quarter of patients with rib fractures are reported to have significant chest wall pain six months post discharge and fifty percent of patients have prolonged disability which is measured by decreased function at work (Gordy et al., 2014). Post discharge

physiotherapy follow up of patients recovering from thoracic trauma and experiencing chronic pain is uncommon (Van Aswegen et al., 2020).

1.2 STATEMENT OF PROBLEM AND JUSTIFICATION FOR RESEARCH

Patients who have suffered thoracic trauma are commonly admitted to emergency units and require prolonged hospital care, depending on the extent of their injuries (Van Aswegen et al., 2011). Pain and immobilisation have deconditioning effects on patients such as loss of muscle strength and respiratory complications (Van Aswegen et al., 2011). A psycho-socio-economic impact on a patient's life results in cases where acute pain becomes chronic pain (Shelat et al., 2012) and chronic pain affects HRQOL as described by Van Aswegen et al. (2011) and Schneiderman, Van Aswegen and Becker (2013). According to Schneiderman, Van Aswegen and Becker (2013) and Van Aswegen et al. (2011), there is a lack of research into how a post discharge physiotherapy intervention impacts chronic pain and HRQOL in South African patients recovering from thoracic trauma. A global study highlighted the need for a post discharge physiotherapy intervention to improve short- and long-term outcomes in patients recovering from major thoracic trauma (Van Aswegen et al., 2020). Further research into the effect of post discharge physiotherapy interventions is therefore needed. Manual release of the intercostal muscles and diaphragm is beneficial to patients with COPD to improve their pulmonary capacity, rib cage compliance, exercise tolerance and HRQOL (Rocha et al., 2015; El-Kady et al., 2018). Following thoracic trauma, the thoracic cage and fascia becomes stiff, and a patient has difficulty moving freely. The effect of manual myofascial release techniques applied to the intercostal muscles and diaphragm on pain levels, pulmonary function, exercise capacity, and HRQOL outcomes for those recovering from thoracic trauma is unknown. Thoracic trauma results in decreased range of motion (ROM) of the thorax (Van Aswegen, 2020). This is commonly because of pain from the rib fractures and intercostal drainage system tubing (Van Aswegen, 2020). Thoracic cage ROM exercises help to improve the thoracic range of motion in patients recovering from thoracic trauma (Van Aswegen, 2020). This can result in decreased level of pain, improved lung function, improved movement of the thoracic cage and therefore an improvement in a patient's HRQOL.

1.3 RESEARCH QUESTION

How does a myofascial release and active exercise therapy programme affect the level of pain, physical function and QOL of adult patients recovering from major thoracic trauma?

1.4 RESEARCH AIM

To determine the outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial release and active exercise therapy.

1.5 RESEARCH OBJECTIVES

- To describe the demographic and clinical profiles (length of hospital stay, diagnosis, mechanical ventilation requirements, previous disability or premorbid condition, pain medication) of adult patients recovering from major thoracic trauma that receive physiotherapy intervention (myofascial release and active exercise therapy) initiated one month after hospital discharge.
- Primary objective: To determine the outcome of a myofascial release and active exercise therapy programme on the level of pain experienced by adult patients recovering from major thoracic trauma over six months.
- Secondary objectives:
  - To determine the outcome of a myofascial release and active exercise therapy programme on pulmonary function and thoracic cage ROM of adult patients recovering from major thoracic trauma over six months.
  - To determine the outcome of a myofascial release and active exercise therapy programme on physical activity and grip strength of adult patients recovering from major thoracic trauma over six months.
  - To determine the outcome of a myofascial release and active exercise therapy programme on the HRQOL of adult patients recovering from major thoracic trauma over six months.

1.6 TYPE OF STUDY

A prospective, longitudinal, quasi-experimental repeated measures design study was conducted.

1.7 HYPOTHESES (NULL)

Adult patients recovering from major thoracic trauma do not experience a significant difference in level of pain, physical function and HRQOL over a six-month period after receiving a myofascial release and active exercise therapy programme.

1.8 DEFINITIONS

Major thoracic trauma can be defined as ‘three or more rib fractures together with pneumothorax, haemothorax or pulmonary contusion which requires management that consists of a minimum of oxygen therapy and pharmacological pain relief strategies’ (Van Aswegen et al., 2020, p.2).This definition of major thoracic trauma was adopted for this study.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

This literature review explores the body structure and function impairments, activity limitations and participation restrictions caused by major thoracic trauma. Specifically, the influence of thoracic trauma on chronic pain, and impairments in pulmonary function (Peak expiratory flow rate (PEFR), maximal inspiratory pressure (MIP)), physical function, thoracic cage ROM, and HRQOL are presented. In addition, existing evidence on exercise and respiratory physiotherapy interventions in patient care post discharge from hospital following thoracic trauma is shared. Lastly, the impact of these interventions on the above-mentioned outcomes is summarised. The validity and reliability of outcome measures used in the management of patients with thoracic trauma is reviewed. Gaps in the existing body of evidence are highlighted.

2.2 METHOD

Relevant articles were sourced using the following search engines: Google Scholar, Pubmed and ScienceDirect via the University of Witwatersrand Library database. The search was conducted between 1998 and 2024. The search terms used were “quality of life” AND “thoracic trauma” OR “chest injury”; “respiratory function” AND “post thoracic trauma” OR “post chest injury”; “physiotherapy intervention” AND “post thoracic trauma” OR “post chest injury”; “pulmonary contusions” AND “respiratory function”; “pulmonary contusions” AND “physiotherapy intervention” OR “rehabilitation”; “soft tissue treatment” OR “myofascial release” AND “thoracic trauma” OR “chest injuries”. A total of 61 articles were reviewed consisting of systematic reviews, randomised and non-randomised controlled trials, narrative reviews, an e-Delphi study scholarly articles, surveys, observational studies, and state of the art reviews.

2.3 DEFINITION, INCIDENCE AND PREVALENCE OF THORACIC TRAUMA INJURY

Thoracic trauma includes lung contusions, pneumothoraces, haemothoraces, pericardial tamponade, injury to the great vessels of the thorax, and rib fractures (Shelat et al., 2012; Van Aswegen and Morrow, 2015). Major thoracic trauma was defined as per the definition above in chapter 1 (Van Aswegen et al., 2020, p.134). This definition was utilised in the current study.

Thoracic trauma accounts for 5.8 million deaths globally and contributes to 25% to 75% of trauma-related deaths (World Health Organisation, 2014; Nadir and Stumpefig, 2019; Beshay et al., 2020). Following cardiovascular diseases and cancer, trauma is the third most common cause of death across all ages (Dogrul et al., 2020). In people under 40 years, trauma is the leading cause of death (Dogrul et al., 2020). A quarter of all trauma cases involves the thoracic region (Beshay et al., 2020). The death rate in developing countries is greatly influenced by trauma with motor vehicle crashes being the leading cause of trauma in these countries (Skinner et al., 2015). After traumatic injury to the head and spinal cord, thoracic trauma is the third most common cause of trauma related mortality and has a mortality rate ranging from 10% to 60% (Kahloul et al., 2020).

Trauma represents a major burden of disease in South Africa with trauma-related incidents accounting for 48,000 deaths annually in South Africa (John and Matshoba, 2015; Skinner et al., 2015). A further 3.5 million people seek healthcare annually as a result of trauma (John and Matshoba, 2015). In KwaZulu Natal, South Africa, 10% of trauma related injuries result in death (Dippenaar and Wallis, 2019). Thoracic trauma accounts for 27% of these deaths (Dippenaar and Wallis, 2019). Of these deaths, 88% are due to penetrating trauma (Dippenaar and Wallis, 2019). The high incidence of trauma in South Africa may be due to poverty, lack of education, unemployment, alcohol and drug abuse, easy access to firearms as well as many other contributing factors (John and Matshoba, 2015). A high mortality rate in thoracic trauma patients gives physiotherapists an indication of the major burden of disease trauma has on an individual. This highlights the importance of new research with aims to decrease this burden.

2.4 MECHANISM OF INJURY IN THORACIC TRAUMA

Thoracic trauma can be classified by the mechanism of injury, namely blunt trauma or penetrating trauma. Blunt thoracic trauma is an injury produced by a force which does not open the thoracic wall contents to the external environment (Van Aswegen and Morrow, 2015; Nadir and Stumpefig, 2019). Blunt thoracic trauma leads to damage to organs without disrupting the tissue integrity (Van Aswegen and Morrow, 2015; Dogrul et al., 2020). Penetrating thoracic trauma is produced by an external force on the body which opens the thoracic wall contents to the external environment (Van Aswegen and Morrow, 2015; Nadir and Stumpefig, 2019). Penetrating thoracic trauma leads to disruption of the underlying tissues (Van Aswegen and Morrow, 2015; Dogrul et al., 2020). Blunt thoracic trauma is usually as a result of motor vehicle crashes, physical

assault and falls, whereas penetrating trauma may be due to gunshots and stab wounds (Van Aswegen and Morrow, 2015; Nadir and Stumpefig, 2019).

Patients with penetrating injuries usually recover faster and often require surgical intervention, whereas those with blunt trauma have a longer recovery time (Fitch et al. 2019). A study in Singapore stated that blunt thoracic trauma is more common than penetrating trauma (Shelat et al., 2012). However, a South African review reported that penetrating thoracic trauma is nine times more common than blunt trauma (Hardcastle et al., 2016).

2.5 PATHOPHYSIOLOGY OF THORACIC INJURY

2.5.1 Cytokine Imbalances

During an injury the body produces large amounts of pro-inflammatory cytokines which causes an imbalance between anti-inflammatory and pro-inflammatory cytokine activity (Van Aswegen and Myezwa, 2008). This leads to excess production and circulation of interleukin-one (IL-1), IL-six (IL-6) as well as tumour necrosis factor-alpha (TNF-α). The release of IL-1 leads to systemic inflammatory response syndrome which causes malaise, fever, and loss of appetite (Winkelman, 2004). Interleukin-one influences insulin-growth factor which causes muscle breakdown. This results in generalised decreased muscle mass (Winkelman, 2004). Interleukin-six results in further release of IL-1 and TNF-α and this leads to further inflammation and further muscle breakdown. Interleukin-six also has a direct effect on muscle breakdown. Prostaglandins result in an increase in infiltration of myocytes (Winkelman, 2004). Tumour necrosis factor-alpha has similar effects to IL-1 (Winkelman, 2004). At the molecular level, the release of pro-inflammatory cytokines can also lead to respiratory insult after chest trauma (Mancini, 2014). These pro-inflammatory mediators that are released are thought to induce secondary cardiopulmonary changes (Mancini, 2014). Secondary cardiopulmonary changes include increased alveolar permeability, alveolar oedema, surfactant dysfunction, decreased lung volume and all leading to hypoxemia (Raghavendran et al., 2009).

Therefore, thoracic trauma has an influence on a patient's cardiorespiratory system at a micro level as well as a macro level (Mancini, 2014). Acute lung injury can result in loss of lung volume, alveolar derecruitment, decrease in positive end-expiratory pressure values, decreased lung compliance and decreased oxygenation (Puybasset et al., 1998; Mancini, 2014). A prospective cohort study which was done by Puybasset et al. (1998), looked at the effects acute lung injury had on lung volume in twenty-one

patients diagnosed with acute lung injury (Puybasset et al., 1998). These patients were admitted with multiple traumas, post operative complications or medical conditions but developed acute lung injury. This study found that acute lung injury resulted in an overall loss of lung volume of 27% predominantly in the lower lobes (Puybasset et al., 1998). Lung areas that were not aerated were along the anteroposterior axis as well as the cephalo-caudal axis (Puybasset et al., 1998). Cephalo-caudal axis measurements decreased by more than 15%. It was also observed that an elevation of the diaphragm occurred in patients with acute lung injury. Elevation of the diaphragm as well as atelectasis of the lower lobes contributes to the decrease in lung volumes basally (Puybasset et al., 1998). This cohort study also showed that alveolar derecruitment occurred mainly along the cephalo-caudal axis (Puybasset et al., 1998). Maggiore et al. (2001) performed a cohort study assessing alveolar de-recruitment and decreasing positive end-expiratory pressure levels in acute lung injury. This study showed that acute lung injury results in a decrease in positive end-expiratory pressure levels in the lungs leading to alveolar closure and therefore decreasing oxygenation (Maggiore et al., 2001).

In any person that has suffered thoracic trauma, the main organ systems that are affected are the respiratory system (pulmonary function) and the skeletal system (chest wall fractures) (Mancini, 2014). Sometimes, depending on the extent of the trauma, the cardiovascular and gastrointestinal systems are also affected. It is therefore evident that a person who has suffered thoracic trauma will have increased ventilatory demands due to pain, collapse of the lung, and blood or air in the pleural space resulting in decreased compliance of the lung tissue (Mancini, 2014).

Pain results in decreased movement of the thoracic cage in the injured region which leads to decreased tidal volume. A decreased tidal volume causes the lung to develop atelectasis and be prone to secretion retention. Due to decreased lung compliance, atelectasis and sputum retention the lung has reduced gaseous exchange causing a low partial pressure of oxygen in arterial blood (May, Hillermann and Patil, 2016).

2.5.2 **Rib Fractures**

Rib fractures are identified in almost 50% of all thoracic trauma patients (Kahloul et al., 2020). Rib fractures can occur in isolation or with other injuries to the head, abdomen, thorax, or the limbs (Maduka et al., 2019). Patients with isolated rib fractures usually have an easier recovery than those with rib fractures and other underlying injuries (Dogrul et al., 2020). The most vulnerable ribs which are easily fractured are ribs four

to 10. The ribs which are less commonly fractured are ribs one, three, 11 and 12 (Kuo and Kim, 2022). The recovery and clinical outcomes of a patient who has sustained rib fractures depends on where the fractures are, how many ribs are fractured and the pattern of the fracture (Maduka et al., 2019).

There are different types of rib fractures. These include simple fractures, multiple fractures, or flail rib injuries. Simple rib fractures are a single break in the rib which usually heals conservatively with pain medication (Pharaon, Marasco and Mayberry, 2015). Multiple rib fractures can include more than one rib fractured as well as one rib fractured in two parts resulting in a floating rib segment (Pharaon, Marasco and Mayberry, 2015). Flail injuries occur when three or more consecutive ribs are fractured in two or more places. This results in floating rib segments adjacent to one another (Pharaon, Marasco and Mayberry, 2015). Multiple rib fractures require pain management as well as treatments to prevent respiratory complications (Pharaon, Marasco and Mayberry, 2015). A flail injury usually leads to a higher mortality and morbidity (Maduka et al., 2019). Patients who sustained flail injuries are more likely to have associated cardiac or thoracic injuries including haemothoraces, pneumothoraces and lung contusions (Maduka et al., 2019). They present with worse respiratory outcomes than those with simple rib fractures (Maduka et al., 2019).

Impact to the upper thoracic region can result in fractures of ribs one to three. These injuries can cause damage to the subclavian vessels and the brachial plexus (Dogrul et al., 2020). Injuries to the middle thoracic region can lead to fractures of ribs four to nine and are usually associated with pulmonary contusions, haemothoraces, pneumothoraces and lacerations. The lower thoracic region and damage to the last two ribs may result in intra-abdominal injuries including liver, kidney, and spleen injuries (Dogrul et al., 2020). The signs and symptoms of a fractured rib include pain over the site, particularly when inhaling or coughing; bruising; feeling or hearing a crack and swelling or tenderness over the site of injury. These signs and symptoms can occur in isolation, or a patient can experience all of them. The severity of these symptoms depends on the number of ribs fractured and the type of fractures (Maduka et al., 2019).

Patients with three or more rib fractures are at a higher risk for pulmonary complications such as acute respiratory distress syndrome, pneumonia and pulmonary contusions which may lead to intubation and mechanical ventilation (Dogrul et al., 2020; Taghavi et al., 2021). Fagevik Olsen et al. (2016) compared patients who

underwent surgical fixation of the ribs to patients managed conservatively following multiple rib fractures. At one year follow-up, 32% who had surgery and 50% managed conservatively reported pain in the rib cage. This study reported that 32% to 37% of patients will experience a degree of chronic pain and fear of movement following major thoracic trauma in the months following their hospital discharge.

2.5.3 Pulmonary Contusions

Pulmonary contusions occur due to high velocity trauma (Pharaon, Marasco and Mayberry, 2015) and result in an accumulation of blood and other fluid within the lung tissue. This is due to alveolar capillary damage and results in hypoxia as the fluid accumulation alters the ability for gaseous exchange to occur (Ahmad Ganie et al., 2013). The patient presents with a ventilation perfusion mismatch and therefore may have difficulty breathing (Ahmad Ganie et al., 2013). Thoracic contusions can lead to respiratory complications such as acute respiratory distress syndrome, pneumonia, and long-term respiratory dysfunction (Ahmad Ganie et al., 2013). Thoracic contusions occur in 25% to 35% of all patients with blunt thoracic trauma and is the most common injury in this group of patients (Ahmad Ganie et al., 2013). Due to impaired gas exchange patients may present with cyanosis, altered respiratory pattern and rate and impaired exercise endurance. At a cellular level, contusions result in inflammation, increased permeability between alveoli and capillaries and pulmonary oedema. Due to the fluid leakage into the lung tissue, the tissue becomes rigid and loses its elasticity (Ahmad Ganie et al., 2013). The alveoli become filled with fluid which causes them to collapse resulting in atelectasis. Collapse of the alveoli is also caused by inactivation of surfactant in the lungs as well as increased secretion retention due to the inflammatory response (Ahmad Ganie et al., 2013). In most cases, thoracic contusions resolve spontaneously in three to five days (Ahmad Ganie et al., 2013).

Carrie et al. (2021) looked at long-term respiratory disability following blunt thoracic trauma in France. Patients included in the study were those who had sustained more than three rib fractures. The average age of these patients was 54 years old and 86% were male and 14% female. Respiratory disability was assessed using a patient's oxygen saturation, forced VC and the New York Heart Association dyspnoea scale (Carrie et al., 2019). At three months follow-up 57% had long-term respiratory disability and 38% of patients reported a significant change in respiratory function when comparing to pre-injury function. At the twelve-month follow-up 28% of patients were found to still have respiratory disability (Carrie et al., 2019). From this study we can

conclude that pulmonary contusions associated with blunt thoracic trauma can lead to long-term complications including respiratory disability and chronic pain.

2.5.4 Pleural Space Disorders

A pneumothorax is when air accumulates in the pleural space. This air lies between the parietal and visceral pleura which compresses the lung (Perkins, 2022). This can be due to an injury to the thoracic cage. Air enters the pleural space and alters the negative pressure resulting in collapse of the lung tissue. Collapse of the lung tissue results in less lung volume (Perkins, 2022).

Traumatic pneumothoraces are caused by an external trauma commonly due to motor vehicle crashes, assaults or falls (Perkins, 2022). A pneumothorax occurs due to the development of a communication between the pleural space and the atmosphere or the intrapulmonary air space and the pleural space (Sharma and Jindal, 2008). A non-penetrating trauma commonly results from a laceration in the visceral pleural from a fractured rib (due to blunt injury) causing air to move from the alveoli through the visceral pleura into the pleural space (Sharma and Jindal, 2008). The external trauma results in air being pulled or sucked into the pleural space (Sharma and Jindal, 2008). This causes a loss of the negative pressure and therefore collapse of the lung (Perkins, 2022). This air continues to enter the pleural space until either there is no difference in pressure between the atmosphere and the pleural space or until the opening is closed (Sharma and Jindal, 2008). An iatrogenic pneumothorax is also caused by a trauma however this trauma is from a healthcare intervention. Examples include a central venous catheter insertion, tracheostomy, biopsy, or intercostal nerve block (Perkins, 2022).

A haemothorax is an accumulation of blood between the chest wall and the pleural space. Trauma results in bleeding within the thorax. This bleeding often comes from laceration of the systemic or pulmonary vessels but may also be from the chest wall, mediastinum, myocardium, abdomen, diaphragm, or the lung parenchyma (Pumarejo Gomez and Tran, 2022). The volume of blood in the hemithorax will determine the severity of the pathophysiologic response (Pumarejo Gomez and Tran, 2022). This blood can cause the lung tissue to be compressed which may cause a lung collapse (Perkins, 2022). The most common cause of a haemothorax is penetrating or non-penetrating trauma. A patient may present with both a haemothorax and pneumothorax also known as a haemopneumothorax (Perkins, 2022).

In the USA, Zeiler et al. (2020) reported on the long-term complications associated with a haemothorax. Twenty percent of patients who underwent drainage of a haemothorax present with a residual haemothorax and of these patients 15% to 30% developed long-term complications (Zeiler et al., 2020). These long-term complications included fibrothorax, empyema and pneumonia (Zeiler et al., 2020). A fibrothorax occurs when the visceral and parietal pleura become fused due to fibrosis. This leads to decreased mobility of the lung which negatively affects respiratory function (Zeiler et al., 2020).

2.5.5 Pulmonary Function and Thoracic Cage Movement

A study conducted in Finland assessed patient's respiratory function on admission to the ward after sustaining rib fractures (Wu et al., 2021). Vital capacity forced expiratory volume in one second and PEFR were assessed. This study concluded that patients with two or more rib fractures present with a decrease in age and height predicted PEFR. This is due to the inability to expand the thoracic cage effectively (Wu et al., 2021). The inability to move the thoracic cage effectively may be due to the fear of movement as well as pain associated with this movement (Wu et al., 2021).

Kim et al. (2021) studied the prevalence of chronic pain in patients' post-thoracotomy for traumatic multiple rib fractures. Forty- seven percent of patients presented with a restrictive respiratory pattern and had a decreased forced expiratory volume in one second value between three months and two years after surgery as reported in this cross-sectional study.

2.6 MANAGEMENT OF PATIENTS WITH THORACIC TRAUMA IN ACUTE CARE

Medical management often includes pain management, fluid resuscitation and respiratory support (Dogrul et al., 2020). Surgical interventions include the management of pneumothoraces and haemothoraces which is dependent on its severity. Small pneumothoraces and haemothoraces may resolve spontaneously with oxygen therapy and rest. A symptomatic pneumothorax or haemothorax will need to be drained by needle aspiration or insertion of an intercostal drainage tube into the pleural space (Perkins, 2022).

2.6.1 Pain Control

The most effective pain therapy is an epidural analgesia (Lovisari et al., 2020). This gives a continuous infusion of analgesia to the patient which blocks the pain. This usually results in an increased compliance from patients in performing breathing

exercises, active coughing, and out-of-bed mobilisation. Studies show that epidural analgesia decreases mortality, pulmonary complications, and hospital length of stay (Lovisari et al., 2020).

The next option for pain relief is regional analgesia. This includes paravertebral nerve block, intercostal nerve block or serratus plane block. Regional analgesia is given directly to a specific nerve, blocking its pain transmission. This type of pain management has less complications with the same effect on the patient's pain as epidural analgesia (Lovisari et al., 2020).

Intravenous analgesia can also be used to assist with pain control. Commonly, opioids and non-steroidal anti-inflammatories are administered intravenously. Intravenous analgesia can result in sedation as well as respiratory depression which leads to further respiratory complications (Lovisari et al., 2020). Pain treatment should be individualised based on each patient's clinical picture.

Post discharge from hospital patients are given oral pain medication. This medication includes simple analgesics such as paracetamol or non-steroidal anti-inflammatories or opioids such as tramadol (Nickson, 2020). Once again, these medications will be prescribed based on assessment of each patient individually. In most cases, pain medications are prescribed until the post operative follow-up with the doctor. The doctor will then review these medications and re-prescribe as necessary.

2.6.2 Oxygen Therapy and Ventilatory Requirements

May, Hillermann and Patil (2016), explain the ventilatory requirements of a patient after sustaining rib fractures. Initially patients are given supplementary oxygen which may include nasal canulae, venturi mask or a polymask. This is dependent on the flow the patient requires to relieve their symptoms of shortness of breath. The oxygen received by the patient needs to be humidified, aiding loosening of secretions in the lungs (May, Hillermann and Patil, 2016). Nebulisation with saline can also be used to assist with loosening secretions making it easier to expel excessive retained secretions. If a patient does not cope on simple supplementary oxygen and their partial pressure of oxygen is not acceptable, the next step would be to use continuous positive airway pressure ventilation (May, Hillermann and Patil, 2016). This can be given non-invasively, requiring the patient to be awake. Continuous positive airway pressure ventilation delivers a positive pressure into the patient's lungs assisting to reduce atelectasis, decrease pulmonary shunting and reduce paradoxical breathing (May,

Hillermann and Patil, 2016). It is however quite uncomfortable for a patient as the patient needs to be awake (May, Hillermann and Patil, 2016).

The last resort if the above-mentioned are not keeping favourable partial pressure of oxygen levels, would be sedating the patient and using invasive mechanical ventilation. This is only used if necessary (May, Hillermann and Patil, 2016). It is therefore important that adequate pain management is given to avoid the need for invasive mechanical ventilation. Effective pain control and respiratory physiotherapy can prevent or reduce the severity of respiratory complications (May, Hillermann and Patil, 2016; Dogrul et al., 2020).

2.6.3 In-Patient Physiotherapy Management

Whilst the injured tissue is recovering, it is important for patients to receive physiotherapy to remove excess pulmonary secretions, perform deep breathing exercises and assist with mobilisation (Ahmad Ganie et al., 2013). Van Aswegen et al. (2020), explored the global physiotherapy management of patients who had sustained major thoracic trauma in acute care settings. The most common physiotherapy interventions used were active cycle of breathing technique (ACBT), deep breathing exercises, active coughing, forced expiratory technique, mobilisation, and body positioning (Van Aswegen et al., 2020). Education was also commonly used to manage the patient's pain. According to Schwellnus, Roos and Naidoo (2017), the most used interventions in patients who underwent open thoracotomies following haemothoraces and pneumothoraces include deep breathing exercises, coughing, early mobility, vibrations of the chest wall, upper limb exercises and thoracic mobility exercises.

A state-of-the-art review by Van Aswegen (2020), reviewed the current literature of physiotherapy for patients post trunk trauma. This review reported that there is lack of literature that describes specific physiotherapy interventions used. The author concluded that the most common physiotherapy interventions used for patient care in hospital included deep breathing exercises, incentive spirometry, active coughing, mobilising the patient away from the bedside, upper limb, and thoracic ROM exercises. Specifically, musculoskeletal interventions included ROM exercises to prevent joint stiffness, improving physical function, improving muscle strength, and optimising exercise endurance (Van Aswegen, 2020). Mobilisation of the patients included sitting on the edge of the bed, sit to stand, sitting in a chair, marching on the spot, walking, stair climbing and running up and down the stairs. This study also highlighted the

importance of education to assist with pain management. This education includes pain neuroscience and pain management as well as techniques to reduce pain such as deep breathing exercises, relaxation exercises and supporting the painful area during coughing (Van Aswegen, 2020). Although these studies indicate that certain treatment interventions are widely used, their effectiveness in altering patients' clinical outcomes remain unclear.

2.7 MANAGEMENT OF PATIENTS WITH THORACIC TRAUMA AFTER HOSPITAL DISCHARGE

Currently the available evidence focuses on physiotherapy management of patients recovering from thoracic trauma in the acute care setting. There is a lack of evidence on post discharge physiotherapy management of such patients.

Van Aswegen et al. (2020) concluded that only eight percent of physiotherapists globally provide patients recovering from thoracic trauma with physiotherapy after discharge from hospital. There is currently no research evidence of the effectiveness of rehabilitation services provided to patients after discharge from hospital following major thoracic trauma (Van Aswegen, 2020).

Battle et al. (2022) conducted an e-Delphi study which highlighted the lack of research supporting post discharge follow-up and rehabilitation of patients after sustaining rib fractures. There is very limited follow-up care of this patient population following discharge from hospital and physiotherapy intervention is usually focused on patient management in acute care settings (Battle et al., 2022).

2.8 CONSEQUENCES OF THORACIC TRAUMA

2.8.1 Chronic Pain

After injury, patients often present with respiratory distress which includes intercostal muscle retractions, the use of accessory muscles, nasal flaring, and an increased respiratory rate (Dogrul et al., 2020). Due to pain, patients mainly breath with the unaffected lung. Pain may also result in changes to a patient's respiratory pattern. These changes include tachypnoea, accessory muscle use and paradoxical chest movement (Dogrul et al., 2020). This results in decreased ventilation to the injured lung leading to atelectasis and secretion retention (Dogrul et al., 2020). There is also damage to the lung parenchyma which alters gaseous exchange. Respiratory

physiotherapy and pain control have an important role in improving the lung function of the patient (Dogrul et al., 2020).

Chronic pain is defined as “pain that lasts more than three to six months, or beyond the point of tissue healing” (Deardorff, 2021, p.2). Chronic pain can be nociceptive, neuropathic and nociplastic. Nociceptive pain is a pain which is caused by damage to a body tissue. In thoracic trauma, the most common type of pain experienced is nociceptive pain (Kela et al., 2021). Chronic pain post trauma contributes significantly to poor QOL and workplace absenteeism (Kahloul et al., 2020). Shelat et al. (2012) conducted a telephonic survey of patients a minimum of one year following traumatic rib fractures. The questions asked to participants included whether they have pain, how severe the pain is and whether the pain affects their HRQOL (Shelat et al., 2012). They found that 19% of patients, who sustained rib fractures, make unscheduled visits to the hospital requesting analgesia (Shelat et al., 2012). Of the patients who still had pain after one year post discharge the mean severity of pain was 3.7 out of ten on the numeric rating pain score scale (Shelat et al., 2012). A numeric rating pain score of 3.7 lies between mild and moderate severity (Boonstra et al., 2016). The authors concluded that acute pain management of these patients is widely researched, however, there is lack of evidence of chronic pain management following rib fractures (Shelat et al., 2012).

Gordy et al. (2014) used the McGill Pain Questionnaire and the Present Pain Intensity Score to assess the prevalence of chronic pain in patients who sustained traumatic rib fractures. A quarter of patients with rib fractures were reported to have significant chest wall pain six months post discharge and 50% of all patients had prolonged disability which was measured by decreased function at work (Gordy et al., 2014). Chronic pain can be described as a major public health problem. Chronic pain negatively influences a patient’s physical function, performance at work, mental health and overall HRQOL (Gordy et al., 2014). Post discharge physiotherapy follow up of patients recovering from thoracic trauma and experiencing chronic pain is uncommon (Van Aswegen et al., 2020).

A study in Tunisia observed patients over a two-month period after sustaining isolated chest trauma (Kahloul et al., 2020). The authors concluded that chronic pain following chest trauma is very common and can be severe (Kahloul et al., 2020). It is therefore necessary to have preventative measures in the acute setting as well as post discharge to combat the development of chronic pain (Kahloul et al., 2020).

A study in Scandinavia reported that patients following multiple rib fractures have a fear of movement one year post injury. The authors compared fear of movement (using the Tampa scale) between a group of patients that received surgical stabilisation for their rib fractures to those who received conservative management. Thirty-seven percent of participants in the conservatively managed group had kinesiophobia at one-year post-discharge compared to 32% of participants in the surgical group. The surgical group had greater thoracic ROM than those managed conservatively (Fagevik Olsen et al., 2016).

A cross sectional study in South Korea was done on the prevalence of post-thoracotomy pain in patients following traumatic multiple rib fractures (Kim et al., 2021). Eighty percent of patients reported chronic pain which was pain experienced at least three months post-operative (Kim et al., 2021).

The long-term complications of patients following isolated rib fractures were investigated in a study with 111 patients. This study found that 64% of patients reported chronic pain and 67% of patients had disability (Fabricant et al., 2013). Carrie et al. (2019) also reported on the long-term complications of patients following rib fractures, with 62% having chronic pain and 57% disability at three months post injury.

It is reasonable to assume, from the information provided, that a proportion of patients will experience a degree of chronic pain and fear of movement as they continue to recover from major thoracic trauma in the months following their hospital discharge.

2.8.2 **Adhesions of the Fascia**

As described earlier, thoracic trauma causes pain in the thoracic region which leads to poor ventilation of the lungs. Short shallow breathing can result in respiratory muscles becoming shortened as they are not moving through maximal inspiration and expiration (El-Kady et al., 2018). This pain also results in fear of movement leading to reduced movement of the thoracic region (NJ Spine and Orthopedic, 2023). Reduced movement of the fascia occurs, and the fascia becomes stiff and can form adhesions (NJ Spine and Orthopedic, 2023). Fascial adhesions attach to the muscles below or develop scar tissue. These adhesions can also entrap surrounding nerves leading to neural pain (NJ Spine and Orthopedic, 2023).

A randomised controlled trial by Rocha et al. (2015) used diaphragm release on patients with COPD. Patients with COPD usually present with decreased diaphragm mobility and general stiffness of the thoracic cage. The manual diaphragm release was used and diaphragm mobility, exercise capacity, maximal respiratory pressures and lung volumes were assessed. The authors concluded that the manual diaphragm release results in improved diaphragm mobility, thoracic cage movement, exercise endurance and inspiratory capacity in patients with COPD (Rocha et al., 2015). The authors hypothesised that the thoracic cage stiffness results from calcification of the joints and cartilages causing decreased vital capacity. The techniques used may have improved thoracic mobility (Rocha et al., 2015). Based on clinical experience, patients with thoracic trauma experience fascial adhesions and therefore stiffness of the thoracic cage and decreased diaphragm mobility. No evidence exists about the effect of myofascial release techniques on pain levels experienced, pulmonary function, thoracic cage movement, or physical activity for those recovering from thoracic trauma. Therefore, the effect of myofascial release of the diaphragm on these outcomes will be assessed in this study, using a pre-post test cohort design, to see if similar results can be produced for adults recovering from thoracic trauma.

The presence of fluid in the pleural space causes a decrease in full inspiration of the lungs and altered diaphragm mobility (El-Kady et al., 2018). The fascia surrounding the respiratory muscles also becomes stiffened and immobile. This leads to reduced thoracic excursion, reduced lung volumes and a stiff rib cage (El-Kady et al., 2018).

2.8.3 Thoracic Cage Stiffness

Traumatic injury to the thorax causes pain and results in splinting of thoracic cage movement, and the diaphragm and intercostal muscles (El-Kady et al., 2018). The insertion of one or more intercostal drainage tubes to address pleural space abnormalities is an additional source of pain that impacts on the patient's ability to freely move their thoracic region (El-Kady et al., 2018). Once the intercostal drain is removed patients may still have pain around the insertion site and from fractured ribs and residual stiffness of the thoracic cage may develop. It is therefore reasonable to assume that those with major thoracic trauma may experience limitations in thoracic cage movement long after hospital discharge due to muscle tightness and mechanical disruption of the stability of the ribcage.

2.8.4 Physical Function and Health-Related Quality of Life

The World Health Organization defines health as: “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” (World Health Organization, 1948). Another definition by the World Health Organisation defines HRQOL as “An individual’s perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns” (as cited in Van Aswegen et al., 2011, p.420). Patients with major trauma are often defined as being severely or critically ill. Critically ill patients have a decreased ability to function due to muscle atrophy that develops from pro-inflammatory and anti-inflammatory cytokine imbalances or prolonged bedrest for fracture management (Van Aswegen and Myezwa, 2008). This results in poor physical function and overall decreased HRQOL after discharge from hospital (Baker et al., 2021). Treatment of critically ill patients was previously focusing on survival, however, recently attention is on the HRQOL of these patients (Hofhuis et al., 2009).

A study by Van Aswegen et al. (2011) was the first to be done in South Africa as well as internationally. This study reported on HRQOL of survivors of penetrating trunk trauma. The results of this study showed initial reductions in HRQOL with improvement over time. Although there was improvement over time, both groups reported problems on at least one of the domains of the SF-36 form. Patients who were on prolonged mechanical ventilation showed physical impairments six months post discharge. This shows a relationship between length of hospital stay and HRQOL post-injury. This study concluded that due to critical illness leading to muscle catabolism, a post discharge rehabilitation programme for these patients is needed (Van Aswegen et al., 2011). Critical illness affects the whole body due to the increase in inflammatory markers. Therefore, it is unclear whether the muscle weakness is due to the critical illness and not only the thoracic injury. Not much has been published on how HRQOL is affected by thoracic trauma alone.

A prospective observational study by Baker et al. (2021), followed patients in the United Kingdom over a six-month period who sustained blunt thoracic trauma. Results showed high levels of pain, neuropathic pain and poor physical function at six months post discharge. The study concluded that HRQOL is affected in these patients six months post discharge (Baker et al., 2021). These patients had poor physical function at six months with chronic pain being the main contributing factor (Baker et al., 2021). Baker et al.’s (2021) study is an observational study which is a low level of evidence.

Therefore, it has low methodological rigor, and we need to interpret their conclusions with caution.

Schneiderman, Van Aswegen and Becker (2011) conducted a retrospective cross-sectional study looking at the HRQOL of South African survivors of thoracic trauma six months after discharge. Twenty-seven participants took part in the study. Participants were found to have problems in all five domains in the EuroQol-5 dimension (EQ-5D) at six months post discharge. Severe problems were shown in the pain or discomfort and anxiety or depression portions of the questionnaire at six months post discharge. Participants were reported not to have achieved optimal HRQOL in any of the domains of the Short Form-36 questionnaire. Results showed problems with work or other daily activities are due to physical health and emotional problems. The factors that affected HRQOL were gender (men reported more pain), age, length of stay (the longer the length of stay, the more limitations in self-care and mobility), and severity of illness (Schneiderman, Van Aswegen and Becker, 2011). This study was small and observational in design and results should be interpreted with caution.

A prospective observational study was done by Fabricant et al. (2013), which looked at prolonged pain and disability after rib fractures. Two hundred and three patients with rib fractures in Oregon, United States of America, were observed post discharge from hospital. Nineteen percent of patients were still taking two or more opioids two months post discharge. Fifty-nine percent of patients had prolonged chest wall pain and 76% had prolonged disability. This study challenges the common thoughts that rib fracture pain resolves by eight weeks and contributes little towards long term disability (Fabricant et al., 2013).

In a retrospective review done by Marasco et al. (2015) in Australia, pain and HRQOL were assessed in patients post trauma with multiple rib fractures. The Short Form-12 Questionnaire was used. This showed very similar pain and QOL results between the thoracic trauma and the multiple trauma groups. This shows the significant impact thoracic trauma has on HRQOL in these patients. The authors concluded that there is a clinically significant decrease in HRQOL up to 24 months post trauma. Only 59% of their participants were able to return to work six months post discharge. Marasco et al. (2015) concluded that due to the significant functional reduction at 24 months, there is a need to further investigate an intervention programme in this population group. Marasco et al.'s (2015) study is a retrospective review which is a low level of evidence.

Therefore, it has low methodological rigor, and we need to interpret their conclusions with caution

Leone et al. (2008) conducted a prospective longitudinal follow up study, researching the long-term outcomes of patients who sustained thoracic trauma. Follow-ups were done at six months and one year post discharge from hospital. Impairments in pulmonary function was the main cause of reduced HRQOL for their participants. The results showed that 65% of the participants reported an impairment of shortness of breath at six months post injury (Leone et al., 2008). This suggests that these patients will have difficulty with activities such as climbing stairs at home or long-distance walking or other forms of aerobic exercise. Inability to perform these everyday activities has a negative impact on a patient's HRQOL (Leone et al., 2008).
A cohort study done by Rainer et al. (2014), found that at 12 months after injury only 19% of post trauma intensive care unit (ICU) survivors reached high functional outcome, while 11% were reported to have moderate disability. They concluded that the main factors which impacted QOL after 12 months was age greater than 65 years old, male gender, health conditions prior to injury, injury severity score, whether they were admitted to ICU, baseline physical component summary, one-month physical and mental component summary and six-month physical and mental component summary (Rainer et al., 2014). Physical and mental component summary was measured with the Short form-36 Health Survey (Rainer et al., 2014).

According to Shelat et al. (2012), in all patients that presented with pain following chest trauma 13% of the patients had reduced HRQOL; 35% of patients reported work related issues, and, in most cases, this was lifting heavy objects; and 26% of patients required regular analgesics to control their pain. These patients were contacted telephonically at a minimum of one year post injury. The authors concluded that a large number of patients post rib fracture present with chronic pain. These patients commonly return to clinics requesting analgesics, extension of their sick leave and enquiries about worker compensation. Twenty-three percent of patients complained of persistent chronic pain. The authors recommended that all rib fracture patients should be followed up for management of chronic pain (Shelat et al., 2012).

Kim et al. (2021) conducted a cross-sectional study in South Korea and reported a decreased HRQOL in patients' post-thoracotomy following traumatic multiple rib fractures. This included impairments in the physical and mental components of the Short Form-12 questionnaire (Kim et al., 2021). Patients with chronic pain reported

worse HRQOL than those without chronic pain (Kim et al., 2021). Fifty-six percent of patients were diagnosed with depression. The study reported that those with chronic pain were more likely to present with depression (Kim et al., 2021).

2.9 PHYSIOTHERAPY INTERVENTIONS THAT MAY RELIEVE THE LONGER-TERM CONSEQUENCES OF MAJOR THORACIC TRAUMA

2.9.1 Exercises to Improve Pulmonary Function

Active cycle of breathing technique (ACBT) is a technique which includes relaxed breathing, lateral costal breathing and forced expiratory techniques (Troughton, 2015). Relaxed breathing focuses on movement of the diaphragm. The diaphragm moves down during inspiration causing the abdomen to move outwards. During expiration the diaphragm moves upward, and the abdomen moves inwards. Before diaphragmatic breathing is performed the patient needs to relax the shoulders and the chest. Following relaxed diaphragmatic breathing the patient performed lateral costal breathing (Van Aswegen and Morrow, 2015; Ahmad, 2018). Lateral costal breathing can be done with a three second hold which assists to recruit collateral ventilation pathways. The recruitment of collateral ventilation pathways assists in mobilising secretions and recruiting collapsed alveoli. The sniffing manoeuvre also increases lung volumes, this is done at the end of a deep inspiration (Van Aswegen and Morrow, 2015; Ahmad, 2018). The inability to cough is usually due to pain from the thoracic trauma. Patients have difficulty clearing the secretions from their lungs. The forced expiratory technique simulates a cough. The patient keeps their mouth open and force air out their lungs. This assists in splinting the airways open and in moving secretions towards the trachea (Ahmad, 2018). For this study, the home exercise programme that participants received included ACBT.

An incentive spirometer is a device which provides visual feedback to encourage maximal inspiration. This increases tidal volumes and mobilises excessive retained secretions from the peripheral to the central airways to improve pulmonary function (Van Aswegen and Morrow, 2015; Ahmad, 2018). The patient is required to exhale fully and then using the device takes a controlled deep breath in. The patient is encouraged to hold the breath for five seconds before exhaling. There are two types of incentive spirometers, a flow device and a volume device. A flow incentive spirometer works with the amount of air inhaled shown by the number of balls lifted. A volume incentive spirometer indicates the volume of the inspired air on a scale on the device (Van Aswegen and Morrow, 2015; Ahmad, 2018). Participants in this study

were tasked to use a volume incentive spirometer as part of their home exercise programme.

Diaphragmatic breathing can stimulate the vagus nerve which will reduce one's stress response. This can cause relaxation of the parasympathetic nervous system resulting in a reduction of anxiety and stress. The decrease in the stress response and overall relaxation may decrease the severity of chronic pain (Bergland, 2017).

2.9.2 Soft Tissue Release Therapy

A systematic review of randomised control trials studied the impact of myofascial release on chronic pain and physical function in a variety of conditions (Ajimsha, Al-Mudahka and Al-Madzhar, 2014). Physiotherapists reported that myofascial release restores the length of the connective tissue which reduces pressure on nerves and blood vessels therefore decreasing level of pain and improving physical function (Ajimsha, Al-Mudahka and Al-Madzhar, 2014). Myofascial release can be used to help relieve pain and to improve function in a wide variety of conditions (Ajimsha, Al-Mudahka and Al-Madzhar, 2014).

Marizeiro et al. (2017) researched the immediate effects of diaphragmatic myofascial release on the physical and functional outcomes in sedentary women. This study was a randomised placebo-controlled trial which was conducted in Brazil. The study found that diaphragmatic myofascial release significantly improved the participant's thoracic wall mobility (Marizeiro et al., 2017). The thoracic wall mobility was assessed using cirtometry in the axillary, xiphoid and basal regions. There was no significant effect on the participant's respiratory muscle strength (Marizeiro et al., 2017).

A randomised control trial in Italy, researched whether manual diaphragm release influences diaphragm mobility, VC, maximal expiratory pressure and sniff nasal inspiratory pressure in patients with COPD (Rocha et al., 2015). This trial reported improvement in all these outcomes following manual diaphragm release. This study reported that longer term effects may occur if this intervention was done with a rehabilitation program (Rocha et al., 2015). This study also states that this intervention did not improve the contractile ability of the muscle (Rocha et al., 2015).

Myofascial release and diaphragm release assists in relaxation and elongation of the respiratory muscles and the fascia (El-Kady et al., 2018). Ultrasonography and spirometry were used to assess patients with pleural effusions following myofascial

and diaphragm release. Myofascial release of the intercostals and the diaphragm resulted in improved VC and diaphragm excursion following pleural effusions. Furthermore, this decreases the risk for pulmonary complications and improves overall HRQOL (El-Kady et al., 2018).

Nagy et al. (2022), performed a randomised control trial in Egypt to determine the effect of diaphragm release and inspiratory muscle training on MIP. The experimental group received the intervention of diaphragm release and inspiratory muscle training and the control group only received inspiratory muscle training (Nagy et al., 2022). The experimental group showed a significant improvement in MIP at the six-week follow-up as opposed to the study group that showed no statistically significant change in MIP (Nagy et al., 2022).

Participants in this study received soft tissue release therapy as part of the physiotherapy follow-up service interventions provided.

2.9.3 Exercise Therapy for Thoracic Cage Mobility

A narrative review by Ahmad (2018), reviewed the essentials of physiotherapy following thoracic surgery. Thoracic surgery can lead to thoracic pain, decreased lung volumes, difficulty taking a deep breath, an ineffective cough, decreased shoulder ROM and retained secretions (Ahmad, 2018). Thoracic mobility exercises include thoracic extension, thoracic rotation to both sides and lateral flexion to both sides. These ROM exercises assist in improving thoracic ROM, improving lung volumes, and preventing long term thoracic cage restrictions (Ahmad, 2018).

Van Aswegen et al. (2020) reported in a global survey that in most countries included in the study, thoracic ROM exercises were not frequently performed by patients although they did present with decreased thoracic cage mobility. They further reported that there is a need for future research on the impact these specific exercises in patients after sustaining major thoracic trauma (Van Aswegen et al., 2020).

Van Aswegen (2020) concluded in a state-of-the-art review that patients following trunk trauma present with impairments in thoracic ROM. This decreased ROM may be due to pain from the rib fractures, the insertion of an intercostal drain or abdominal distention. Thoracic ROM exercises are prescribed to these patients to assist with improving thoracic mobility, prevention of joint stiffness and to improve general functionality in this patient group (Van Aswegen, 2020).

2.10 OUTCOME MEASUREMENTS USED FOR THIS STUDY TO ASSESS RECOVERY OF PATIENTS WITH THORACIC TRAUMA

2.10.1 Pain

The Brief pain inventory (BPI) was used to assess clinical pain. This questionnaire allows an individual to rate the severity of their pain as well as how it affects their function (Cleeland, 2009). The BPI has been validated and shown to be reliable in several different pain-causing conditions. It is a recommended tool to use for evaluating the effect of treatment of pain and how it affects a patient's functional ability (Correll, 2007). The BPI has good construct validity (Poquet and Lin, 2016). This questionnaire has good retest reliability for malignant pain and shows good reliability for pain intensity (Poquet and Lin, 2016). Baker et al. (2021), reported on the HRQOL and long-term outcomes of patients following blunt thoracic trauma and used the BPI to assess chronic pain in these patients.

2.10.2 Respiratory Function

2.10.2.1 Peak expiratory flow meter

The PEFR is defined as 'the maximum velocity of flow with which air is forced out of the lungs' and is expressed in L/min (Reshmarani, Shilpa and Veena, 2020, p.2). Age, gender and anthropometry as well as one's respiratory muscle strength influences PEFR measurement (Reshmarani, Shilpa and Veena, 2020). Peak expiratory flow rate is usually greater in males as compared to females and is also shown to be higher in patients that are taller (Reshmarani, Shilpa and Veena, 2020).

Reshmarani, Shilpa and Veena (2020) compared a peak flow meter and a digital spirometer in 200 healthy males. A comparison between these two devices was done to determine any significant differences in measuring PEFR. All participants were shown the correct procedure for recording PEFR. The procedure was done with the participant in a seated position. They compared a mini-Wrights peak flow meter device and a Spirolab 3 computerised spirometer. Both values were recorded in litres per minutes and the best value of three readings were selected. Results showed the peak flow meter was cost effective and the participants could use the device easily at home. The peak flow meter was also shown to give consistent readings with three attempts on the device and was as effective as the digital spirometer (Reshmarani, Shilpa and Veena, 2020).

Based on this information, the peak flow meter was included as an outcome to assess changes in pulmonary function for this study.

2.10.2.2 **POWERbreathe device**

Maximal inspiratory pressure can be used to assess a patient's inspiratory muscle strength (Pessoa et al., 2014). This measurement can be assessed by a patient inspiring forcefully through a resisted device such as a POWERbreathe device (Pessoa et al., 2014). The result of an assessment is very dependent on the effort of the patient (Pessoa et al., 2014). A decreased MIP can indicate weak inspiratory muscle strength but also in some cases poor effort from the patient (Pessoa et al., 2014). It is therefore important that the test is thoroughly explained to the patient to try and obtain a good effort (Pessoa et al., 2014). There is no normal value for MIP as it can be affected by many variables (including height, gender, age, co-morbidities, etc.), however a rough 'normal' for adults is suggested to be around 80mmHg (Pessoa et al., 2014).

A study by Lee et al. (2016) researched the inter-rater and intra-rater reliability of the POWERbreathe device to assess MIP, peak inspiratory flow and vital VC on patients following stroke. The intraclass correlation coefficients for MIP, peak inspiratory flow and VC were 0.986, 0.992 and 0.959 respectively for intra-rater reliability. The intraclass correlation coefficients for MIP, peak inspiratory flow and VC for inter-rater reliability were 0.984, 0.985 and 0.933 respectively. This shows good intra-rater and inter-rater reliability for measuring MIP, peak inspiratory flow and VC using a POWERbreathe (Lee et al. 2016).

The validity of the POWERbreathe device was also researched by Langer et al. (2013). The study included 35 patients with moderate to severe COPD. The POWERbreathe was compared with data obtained by external laboratory measurement equipment. Results showed good validity of the POWERbreathe in measuring MIP, average mean power per breath, average duty cycle (also known as the I:E ratio) and total inspiratory work when compared to measurements taken with external laboratory equipment in patients with COPD. Maximal inspiratory pressure is commonly used to assess respiratory muscle strength in patients with spinal cord injuries, COPD and those with respiratory muscle weakness due to prolonged ventilation (Langer et al., 2013). It can be used in patients recovering from thoracic trauma; however, there is lack of research in this area (Physiopedia, 2021).

This is the first study to include MIP assessed with the POWERbreathe device as an outcome for patients recovering from major thoracic trauma.

2.10.3 Thoracic Cage Mobility

Currently, the measurement of thoracic ROM is dependent on clinician observation and there is no standardised outcome measure. Johnson et al. (2012) researched the reliability of thoracic spine rotation ROM measurements in healthy adults. They compared five different ROM techniques over two days. These techniques included seated rotation (bar in back and front), half kneeling rotation (bar in back and front) and lumbar locked rotation. The inter-rater and intra-rater reliability was assessed.

All inter-rater and intra-rater intraclass correlation coefficient values were greater than 0.85. This indicates a good reliability (Johnson et al., 2012). All techniques had a low measurement error. All five techniques can be used if the same examiner obtains measures at follow up sessions (intra-rater reliability). For best inter-rater reliability the lumbar locked technique and the seated rotation technique with the bar positioned in the front are recommended. The standard error of measurement and minimal detectable change were low for all techniques. This indicates changes in ROM can be consistently identified with these techniques (Johnson et al., 2012).

The range of motion measurements described above were included in this study as outcomes to monitor changes in thoracic ROM.

2.10.4 Physical Function

The International Physical Activity Questionnaire (IPAQ) is a self-reported outcome measure which assesses the physical activity of individuals throughout the day. It further looks at the type of physical activity, the intensity of activity and the time spent sitting during daily life (Craig et al., 2003). Test-retest reliability data for the IPAQ was shown to be good with a very good repeatability (correlation coefficients ranging from 0.88 to 0.32) (Craig et al., 2003). This questionnaire is valid and reliable in developed as well as developing countries across a wide range of conditions (Craig et al., 2003). This study included the South African population. The information shared in this chapter shows that thoracic trauma affects physical function. This outcome measure was used to assess changes in physical function throughout the intervention period.

A handheld dynamometer was used to assess the participant's handgrip strength. A systematic review by Mafi et al. (2012) reported that handheld dynamometry showed acceptable to high reliability regardless of the medical condition of the patient. Handheld dynamometry can be used to predict the outcome in men and the survival rate in women (Mafi et al., 2012). Handheld dynamometry is a cheap, simple, reproducible, objective, and sensitive tool used to assess general muscle strength (Mafi et al., 2012). Handgrip muscle strength can be used as a measure of overall muscle strength (Mafi et al., 2012). A cohort study in Brazil compared the Medical Research Council Scale to handgrip strength in assessing patients for ICU acquired weakness (Braganca et al., 2019). They concluded that handgrip dynamometry can be used as an alternative to the Medical Research Council Scale in assessing patients for ICU acquired weakness (Braganca et al., 2019).

2.10.5 Quality of life

The EQ-5D is an outcome measure which assesses an individual's HRQOL. The EQ-5D has five domains which include mobility, selfcare, usual activities, pain or discomfort and anxiety or depression (Angus and Carlet, 2003). The EQ-5D has been recommended as the best suited instrument for measuring HRQOL in a critical care setting (Angus and Carlet 2003). The EQ-5D is designed to be used for a wide range of conditions as opposed to one disease (Brooks, 1996; Lou et al., 2003). The EQ-5D is valid and reliable in the general population and various patient groups (intraclass correlation coefficients of 0.75) (Brooks, 1996; Lou et al., 2003). This outcome measure was used previously in a South African group of trauma patients, of which some had thoracic trauma, to assess their HRQOL post discharge from hospital (Schneiderman, Van Aswegen and Becker, 2013). As it was utilised in a group of South African thoracic trauma patients previously, it was included as an outcome measure in this study.

2.11 CONCLUSION

From the literature presented in this review it is evident that patients who sustained major thoracic trauma often face long-term challenges as they recover from their injury. These challenges include chronic pain, respiratory complications, problems with physical function and changes in HRQOL. The respiratory complications include decreased lung volumes, secretion retention and decreased respiratory muscle strength. There is limited research on whether an outpatient rehabilitation program after discharge will benefit this patient population. Some research on myofascial release in patients with COPD, COVID-19 and pleural effusion have shown favourable

results in improving respiratory function. As mentioned earlier, there is currently no research on myofascial release in patients post thoracic trauma. This shows the novelty for research in this area. More research and subsequent evidence are needed to identify whether an outpatient program including myofascial release, thoracic ROM exercises and breathing exercises impacts on a patient's level of pain, respiratory function, functional abilities and HRQOL as they recover from major thoracic trauma.

CHAPTER 3

3. METHODOLOGY

3.1 ETHICAL CONSIDERATIONS

Ethical clearance to perform this study was obtained from the University of the Witwatersrand Human Research Ethics (Medical) Committee (Certificate number: M220225) (Appendix A). Permission to perform the study in hospitals belonging to the Netcare group was obtained from the Netcare Research Ethics Committee (Certificate number: UNIV-2022-0037) (Appendix B). Permission was also obtained from the hospital management of Netcare Union (now Netcare Alberton) (Appendix C) hospital to access patient's ICU charts and files and to recruit patients for this study prior to their discharge. Permission was obtained from the physiotherapy practice of Plani, Laidler, Fleishman, Sklaar and Associates (Appendix D) to conduct the post-discharge assessment and treatment of these participants in their rooms in Alberton. Participants were allowed to withdraw from this study at any time. Participants were not required to pay for the intervention received or transport costs to get to the physiotherapy practice as this cost was covered by the supervisor's research grant. The researcher completed an online research ethics course prior to commencement of participant recruitment (TRREE) (Appendix E).

3.1.1 Anonymity of Data

All data obtained from participants was coded and captured on data capture forms using each participant's unique study identification code to ensure anonymity. On all data sheets and appointment cards, only the participant code appeared. Forms with the participants names, study identification codes, and personal details were kept separate from all other documents and were password protected. By doing this, confidentiality and safe keeping of participant details were ensured. The participants' list was destroyed by the researcher at the end of the study. Data captured in REDCap (Wits University) will be kept indefinitely. The data will be accessed by the researcher and a link to the data will be shared with the researcher's supervisor.

3.1.2 Informed Consent

All participants were provided with an information document explaining the study and questions they had about the study were answered by the researcher in the presence of a healthcare practitioner known to the participant. Once the questions were answered written informed consent was obtained if they agreed to participate. All

participants had the right to withdraw from the study at any given time without prejudice or any penalty. Such participants did not have to provide any reasons for withdrawal from the study. All participants had the right to access their own study results if they wished to see it. The results of this study will be made publicly available, and the researcher will attempt to publish the results in a suitable peer-reviewed journal.

3.1.3 Participant Referral to Specialised Services

Participants were referred to any relevant services if they had complaints other than those treated in the study. These services included a psychologist, a doctor, and an occupational therapist. This was done during the study, as soon as the participants required these services.

3.2 STUDY DESIGN

A prospective, longitudinal, quasi-experimental repeated measures design was used to answer the study objectives.

3.3 STUDY SETTING

3.3.1 Study Location

The study setting was Netcare Alberton hospital which is a level one accredited trauma private hospital in Alberton, Gauteng. The hospital has 427 beds, 24 of these beds being trauma ICU beds and a 31-bed trauma ward. A global survey showed that the most frequently used interventions for acute patients with major thoracic trauma include deep breathing exercises, ACBT, ambulation and positioning for ventilation-perfusion matching (Van Aswegen et al. 2020). This study included hospitals in South Africa. At this participating private hospital patients with thoracic trauma receive routine in-hospital physiotherapy which is dependent on individual patient assessment findings and is similar to that described in the global survey. Interventions used for in-patient management, in addition to those described, include manual chest physiotherapy techniques (percussions and vibrations as indicated), and thoracic cage ROM exercises. There is currently no routine post discharge physiotherapy follow up for patients who have sustained thoracic trauma. Participants attended the private physiotherapy practice rooms for their post-discharge management.

3.3.2 Duration of Study

Participant recruitment took place from June 2022 to February 2023 (nine-month period). Data collection took place from July 2022 to June 2023.

3.4 PARTICIPANTS

3.4.1 Eligibility Criteria

Patients admitted for management to Netcare Alberton hospital trauma unit after sustaining major thoracic trauma were invited to participate in this study prior to their hospital discharge. All trauma patients were screened by physiotherapists and treatment was initiated if indicated. Patients who sustained thoracic trauma are not routinely followed up after hospital discharge by the private practice physiotherapists. Potential participants were screened consecutively for suitability of participation against the predetermined study criteria:

3.4.1.1 Inclusion criteria

- Adult (18 years and older) male and female patients;
- Standardised 5-questions score of 5/5;
- Glascow Coma Scale score of 15/15;
- Sustained major thoracic trauma:
  - "Three or more rib fractures" AND/OR
  - "The presence of a tension pneumothorax, open pneumothorax, flail chest injury, pulmonary contusion, and/or massive haemothorax" (Van Aswegen et al., 2021, p.2) AND/OR
  - Sustained sternal fractures

3.4.1.2 Exclusion criteria

- Acute or previously diagnosed traumatic brain injury with cognitive impairment;
- Acute or previously diagnosed spinal cord injury;
- Diaphragm rupture that requires surgical repair;
- Unstable vertebral fractures;
- Extensive abdominal trauma;
- Burns over the trunk;
- Amputation of the upper or lower limb/s;
- Patients residing in correctional facilities or pending investigations.

3.4.1.3 **Withdrawal Criteria**

- Participants who sustained an unrelated second chest trauma injury after hospital discharge were withdrawn from the study;
- Participants who choose to withdraw their consent.

3.4.2 **Sample Size Estimation**

The primary outcome for this study was the level of pain experienced pre-intervention vs post-intervention. Pain is often measured using the Brief Pain Inventory (BPI). The minimum clinically important differences (MCID) for BPI average pain score and BPI severe pain score reported by Mease et al. (2011) for a fibromyalgia population over a 12-week period were 2.1 and 2.2 points respectively (no data exists for the trauma population). Using a sample size calculator for pre- and post-intervention design (http://sample-size.net/sample-size-study-paired-t-test/), with effect size of 2 points difference and standard deviation (SD) of 2 as change in the outcome for BPI (Mease et al., 2011), a sample size of 10 subjects was obtained (alpha = 5%, beta = 20%). Considering an estimated rate of 46-54% default in attendance by six months as reported in other follow-up studies performed in Gauteng (Van Aswegen et al., 2010; Van Aartsen and Van Aswegen, 2018), the sample size estimation was increased to 25 subjects. Thirty-five participants were recruited for the study.

3.4.3 **Sample Selection**

Consecutive patient sampling was done for all patients admitted to the ICU and wards of Netcare Alberton Hospital. Each patient admitted to the Netcare Alberton Hospital was screened to determine whether they met the eligibility criteria for this study. Those who met the criteria were available for potential recruitment in the study. Recruitment to the study depended on the participants willingness to participate. Only those who provided written consent were entered into the study.

3.5 **DATA COLLECTION PROCEDURE**

3.5.1 **Pilot Studies**

3.5.1.1 **Pilot study one**

3.5.1.1.1 Objectives

To establish the time needed for participants to complete the EQ-5D, BPI and IPAQ questionnaires.

3.5.1.1.2 Procedure

The researcher and one research assistant (senior physiotherapist) were responsible for the EQ-5D, BPI and IPAQ assessments of study participants. The number of participants recruited for this pilot study was three, representing 10 percent of the estimated sample size of 30 participants. The researcher administered the EQ-5D, BPI and IPAQ once on each of the three participants on separate occasions in the hospital ward by their bedside. The questionnaire was explained to each participant prior to completion and consent was obtained from each participant. The time taken for each participant to complete each questionnaire was recorded.

The total time to complete the EQ-5D was two minutes, two minutes 30 seconds and two minutes; the BPI was two minutes, three minutes and three minutes; and the IPAQ was two minutes, three minutes and two minutes 30 seconds. This time was assessed to establish the amount of time that would be needed for the administration of the questionnaires during the main study.

3.5.1.2 **Pilot study two**

3.5.1.2.1 Objectives

To familiarise the researcher and research assistant with the assessment technique used to assess thoracic cage ROM for thoracic rotation using a goniometer. To determine the inter-rater and intra-rater reliability of the thoracic rotation ROM assessment of the researcher and the research assistant.

3.5.1.2.2 Procedure

Three participants were recruited for pilot study two. These participants fitted the inclusion criteria for the main study. The participants were in the acute hospital setting and their pain was well controlled. The researcher and research assistant performed the thoracic rotation ROM measurements using a goniometer three times to each side on each participant. The technique used was based on the technique described by Johnson et al (2012). This technique is explained in Appendix F. The researcher and the research assistant performed the technique on each participant three times to each side with a 30-minute break between assessments. The assessment of thoracic ROM was done to both the right and left sides. No changes were made to the testing procedure laid out for the main study.

From the results of this pilot study, it was concluded that the inter-rater reliability showed a high correlation between assessors with a Pearson correlation of r=0.94 to the right side and r=0.98 to the left side. The correlation was not significant to the right side with a p-value of 0.08 and significant to the left side with p-value of 0.01. The small sample size may be the reason for the correlation not being significant to the right side (Appendix F).

The intra-rater reliability was good. The level of association between measurements taken by the researcher for thoracic rotation ROM to the right side was high (r=0.99) and moderate to the left side (r=0.5). The level of association between measurements taken by the research assistant for thoracic rotation ROM to both sides was high (r=0.95 and r=0.9, respectively). (Appendix F).

3.6 MAIN STUDY

3.6.1 Initial Contact

The researcher monitored admissions to the trauma ICU and wards on a weekly basis. A consecutive sampling technique was used. The admission records of the respective trauma wards were searched for those patients who fitted the study inclusion criteria. Subjects were approached 24 hours after transfer from trauma ICU to the trauma ward. Subjects were given a participant information sheet (Appendix G) and consent form (Appendix H). Subjects were given 24 hours to decide on their participation and were followed up regarding their decision. Upon receiving written consent, the researcher collected their baseline data prior to their hospital discharge.

3.6.1.1 The baseline data collection

Participants were approached in their ward by the researcher prior to discharge. The questionnaires were explained to the participants, and they were allowed to ask questions at any time. Participants completed the demographic questionnaire (Appendix I); EQ-5D questionnaire (Appendix J), BPI (Appendix K) and EQ-5D VAS scale (Appendix L) based on prior to discharge condition. Participants also completed the EQ-5D (including VAS) based on their pre-injury status. They were given a physiotherapy appointment for four weeks post discharge at the private physiotherapy rooms in Alberton.

3.6.2 Initial Appointment (four weeks post discharge)

Participants were telephonically contacted and reminded about their appointment 24 hours before the day of their appointment. On the day of the first appointment, the researcher or the research assistant took participants into a quiet room with sufficient lighting and ventilation. The following assessments were then done: completion of the EQ-5D, BPI and IPAQ (short version) questionnaires (Appendix M); measurement of thoracic cage ROM; assessment of PEFR and MIP; and measurement of handgrip strength using a CAMRY Digital Handheld Dynamometer. The treating physiotherapist then took over to commence the intervention. The intervention was determined based on the outcome measures selected. Myofascial release has been shown to improve clinical outcomes in COPD but there is no literature on the use of this intervention in patients with thoracic trauma. The intervention included myofascial release and trigger point release of the diaphragm and intercostal muscles; heat therapy of the affected area (5 minutes); thoracic cage ROM exercises; and education on a home exercise programme which included thoracic cage ROM exercises, ACBT and incentive spirometry. Participants were given an exercise recording sheet to record their home exercise program (Appendix N).

All assessment techniques and demonstration of the home exercises programme were done by the researcher. The myofascial release techniques were performed by one of the physiotherapists working at the private practice. The treating physiotherapist received training from an experienced physiotherapist in neuromusculoskeletal therapy on the myofascial techniques prior to the commencement of the study. Data was captured on outcome measure sheets (Appendix O). Participants received their transport money prior to departing the private physiotherapy practice.

3.6.3 Second Appointment (two months post discharge)

The second appointment included the same interventions as described above.

3.6.4 Third Appointment (three months post discharge)

The third appointment included the completion of the intervention sessions; reassessment of the EQ-5D, BPI, thoracic cage ROM, MIP, PEFR, handheld dynamometry and IPAQ. The participants were then informed that they would be contacted in three months for their six-month post discharge telephonic follow-up.

3.6.5 Final Telephonic Follow-Up (six months post discharge)

Participants were telephonically contacted by the researcher for a final reassessment of the EQ-5D, BPI and IPAQ scores.

3.7 VARIABLES

3.7.1 Dependent variables

3.7.1.1 Primary outcome

The primary outcome is level of pain (EQ-5D VAS and BPI).

3.7.1.2 Secondary outcomes

The secondary outcomes are HRQOL using the EQ-5D questionnaire (5L); PEFR using the hand-held peak flow meter device (Brand: Findel International); MIP using the POWERbreathe KH2 device; Trunk active ROM using a goniometer; Physical activity using the IPAQ (Short version)**;** and Handgrip muscle strength using a CAMRY Digital handheld dynamometer.

3.7.2 Independent Variables

The independent variables included myofascial release of the intercostal muscles and the diaphragm and home exercise programme including active thoracic cage ROM exercises, ACBT and incentive spirometry.

3.7.3 Confounding Variables

The confounding variables included smoking and underlying health conditions.

3.8 OUTCOME MEASURES AND INSTRUMENTATION

The order in which outcome measures were assessed at the respective time points was not randomised. The duration of time to complete assessments of all outcomes took on average thirty minutes per participant.

3.8.1 Peak Expiratory Flow Rate

A hand-held peak flow meter device (Brand: Findel International) was used to assess PEFR. The correct technique for PEFR measurements was explained by the researcher to each participant. They were asked to sit on a chair with their feet flat on the floor and their back supported. The marker on the side of the peak flow meter was set on zero. The patient was instructed to inhale fully, place their lips around the device (ensure a complete seal) and exhale as fast and forcefully as possible. A mouthpiece was used for infection control. This was done three times, and the highest value was

recorded as the participant's best effort at that assessment (Reshmarani, Shilpa and Veena, 2020).

3.8.2 Thoracic Rotation ROM

A goniometer was used to assess thoracic ROM. The methods for assessment of thoracic ROM, described by Johnson et al. (2012), were adopted for this study.

Range of motion measurements were taken at the level of T1-T2 as this is where the most motion occurs. The seated rotation test was used. The participant was seated with their hips and knees flexed at ninety degrees with a ball (21cm diameter) placed between their knees. A polyvinyl chloride pipe measuring 105cm (diameter 2.5cm) with a mark in the centre was used to standardise the position of the upper limbs. The bar was then placed in the front of the patient's chest with their arms crossed over the bar. The goniometer was placed parallel to the ground between the T1 and T2 spinous process. The spine of the scapula was used as a reference point. The stationary arm was pointed away from the rotation side and remained parallel to the starting position. The participant was instructed to maximally rotate to the side to be tested and the examiner followed the motion with the moving arm of the goniometer. Each measurement was taken three times, and the best value was used (Johnson et al., 2012) (Fig. 3.1-3.3).

Figure 3.1: Starting Position for Thoracic ROM Assessment.

Figure 3.2: Placement of Goniometer prior to Rotation

Figure 3.3: Placement of the Goniometer after Thoracic Rotation

3.8.3 Maximal Inspiratory Pressure

The participant's MIP was measured using a POWERbreathe KH2 device. Three readings were taken, and the best value of the three was recorded as the participant's best effort at the time of assessment (Lee et al., 2016). The participant was asked to sit on a chair with their feet supported. The participant's hips and knees were at ninety degrees. A nose clip was used to block the participant's nose and a filter was used for

infection control. The participants were instructed to take a deep, forceful breath in against the resistance provided by the device, hold their breath for 2 to 3 seconds and then to do a complete expiration. The researcher then recorded the MIP. Three readings were taken, and the best value was recorded for the participant at the time of the assessment (Lee et al., 2016).

3.8.4 Health-Related Quality of Life

Health-related quality of life was measured using the EQ-5D which was self-administered. The researcher or the research assistant was present when the questionnaire was being completed and assistance was provided if the subject did not understand what was being asked. No attempts from the researchers were made to influence the subject's response to the questions in the questionnaire. None of the participants required assistance. The questionnaire is available in Afrikaans, English, Sesotho, Zulu, Xhosa, Northern Sotho and Setswana. The appropriate version was made available according to participant preference; however, all the participants requested the English version.

3.8.5 Level of Physical Activity

The IPAQ was used to assess physical function and was self-administered. The researcher or research assistant was present when the questionnaire was being completed and assistance was only provided if the participant did not understand what was being asked. No attempts from the researchers were made to influence the participant's responses to the questions. None of the participants required assistance. The IPAQ is not available in any other South African languages besides English. An interpreter was available if needed however none of the participants needed assistance.

3.8.6 Level of Pain

The BPI was used to assess the level of pain and was self-administered. A researcher was present when the questionnaire was being completed and assistance was only provided if the participant did not understand what was being asked. No attempts from the researchers were made to influence the participant's response to the asked questions. None of the participants required assistance. The questionnaire is available in Afrikaans, English, Sesotho, Zulu, Xhosa and Northern Sotho. The appropriate version was made available according to participant preference; however, all the participants requested the English version.

3.8.7 Handgrip Muscle Strength

The participants' handgrip strength was measured using a handheld dynamometer (Fig. 3.4). Three measurements were taken for the patient's dominant hand and the best value was recorded at the time of assessment (Performance Health, 2024). The participant was seated with their shoulder adducted, elbow flexed to 90 degrees, and forearm and wrist in neutral. The researcher then placed the dynamometer in the participant's hand and instructed the participant to squeeze as hard as possible. The participant was encouraged to perform a smooth grip action without any jerking movements. The researcher allowed extension of the wrist during the assessment. Three measurements were taken for the patient's dominant hand and the best value was recorded at the time of assessment (Performance Health, 2024).

Figure 3.4: Handheld Dynamometer Device

3.9 INTERVENTIONS

3.9.1 Myofascial Release of the Diaphragm

The treatment strategy described by El-Kady et al. (2018) was adopted for this study. Myofascial release of the diaphragm was done with the participant in a supine position with their knees and hips flexed to 90 degrees. The treating physiotherapist placed her pisiform, ulnar edge and the last three finger pads on the underside of the participant's costal cartilage of the 7^{th}, 8^{th}, 9^{th} and 10^{th} ribs and guided her forearm to the same side shoulder of the participant. During inspiration, she pulled both points of contact towards the participant's head and slightly laterally. During expiration, the treating physiotherapist deepened contact towards the inner costal, and maintained resistance throughout inspiration. This was done for ten breaths and repeated for two sets with a one-minute rest in between (El-Kady et al. 2018). Trigger point release of the diaphragm was performed with the participant in a supine position with their knees and hips flexed to 90 degrees. The treating physiotherapist palpated the diaphragm and felt for fascial restriction. If restriction was felt, the research assistant applied a gentle

pressure on this area until they felt the resistance release. This was repeated throughout the entire length of the muscle (Bordoni et al, 2016).

Trigger point release of the diaphragm is performed with the patient in a supine position with their knees and hips flexed to 90 degrees (Bordoni et al., 2016). The physiotherapist palpates the diaphragm and feels for fascial restriction. If restriction is felt, the physiotherapist applies a gentle pressure on the area until the resistance releases. This is repeated throughout the entire length of the muscle (Bordoni et al., 2016) (Fig. 3.5).

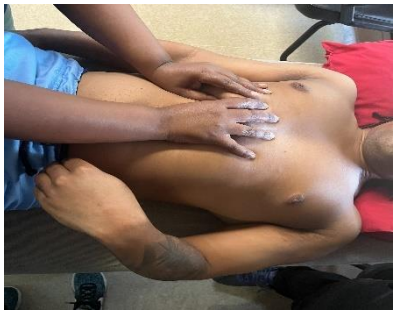

Figure 3.5: Hand Placement for Trigger Point Release of the Diaphragm

3.9.2 Myofascial Release of the Intercostal Muscles

Myofascial release of the intercostal muscles was done with the participant in a seated position, and was instructed to take a deep breath in. During exhalation, the treating physiotherapist applied a gentle downward pressure on the patient's lower ribs. The participant was encouraged to reach overhead to the opposite shoulder during exhalation. This was done for ten breaths and two sets with a one-minute rest in between (El-Kady et al., 2018) (Fig. 3.6).

Trigger point release of the intercostal muscles was done with the participant in side-lying. The treating physiotherapist palpated along the intercostal muscles starting superiorly and moving inferiorly (Fig. 3.7). If tension was felt along the muscle, the physiotherapist applied a gentle pressure until the muscle softened under their fingers. This was continued until all points of tension were released (Painotopia, 2021).
Participants were assessed prior to the treatment by the researcher. In cases where the participant still had a lot of pain, the research assistant adjusted the treatment as needed and this was documented. The amount of pressure applied was adjusted based on the participant's perceived level of pain.

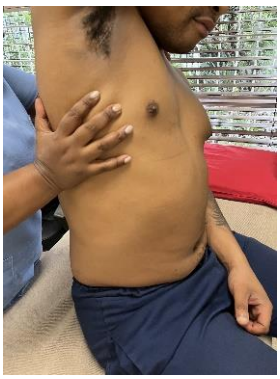

Figure 3.6: Hand Placement for Myofascial Release of the Intercostal Muscles

Figure 3.7: Hand Placement for Trigger Point Release of the Intercostal Muscles

3.9.3 Thoracic Range of Motion Exercises

Thoracic ROM exercises were done with the participant seated with their feet and back supported. Thoracic extension involved the participant placing his or her hands behind their neck. The participant was then instructed to move his or her head backwards and to slowly extend the thoracic spine (Fig. 3.8). Thoracic rotation involved the participant crossing his or her arms across their chest and slowly turning their chest as if they were trying to look behind one side and then the other (Fig. 3.9). The participant inhaled before rotating, then rotated to the one side holding their breath and exhaled at the end of the rotation. They then repeated the same action to the opposite side. The breath hold ensured a stretch on the hemidiaphragm fibres. Thoracic lateral flexion involved the participant crossing his or her arms over the chest and then slowly bending the trunk from side to side (Ahmad, 2018) (Fig. 3.10). Thoracic ROM exercises were done for 8-10 repetitions and one set was done. This was progressed to 12 repetitions and three sets. These exercises were given twice a day, five days per week. These exercises were given at the first follow-up after hospital discharge. At the two-month follow-up the participants were advised to do the exercises once daily and to increase the number of repetitions to 20 per set as their condition allowed. Intervention was a combination of myofascial release and active exercises.

Figure 3.8: Thoracic Extension Exercises

Figure 3.9: Thoracic Rotation Exercises

Figure 3.10: Thoracic Lateral Flexion Exercises

The participants were given a home exercises programme by the researcher which included the above-mentioned thoracic ROM exercises as well as deep breathing exercises. A logbook was used for participants to monitor their home exercises.

3.9.4 Respiratory Exercises

The deep breathing exercises included in the home programme were the ACBT as well as incentive spirometry. The participant was instructed to sit on a chair with a back support. The participant performed ten shoulder rolls forwards and backwards to relax their shoulder girdles. The participant was instructed to place their hand on their abdomen and take normal breaths while feeling their stomach rise and fall. The physiotherapist placed their hands on the lateral aspects of the participant's chest providing a tactile input and the participant needed to breathe in as deep as they can. The participant took a deep breath in feeling the lower chest move outwards. This was followed by taking a deep breath in and holding the breath for three seconds. Lastly, the participant took a deep breath in, sniffed extra air in through the nose and then breathed out. Each technique was repeated three times.

The next technique was called huffing. The participant opened their mouth halfway and forced air out their mouth (as if steaming up a mirror). Lastly, the participant coughed to clear any loose secretions. These exercises were given at the first follow-up after hospital discharge. This cycle was completed three times and done twice a day for the first month. Thereafter, at the two-month follow-up, daily five days per week (Monday to Friday) (Rib Injury Clinic, 2021).

Incentive spirometry was performed with the participant in the same position. The volumetric incentive spirometer devices were used (LungVital Pro Breathing Exercise Spirometer), as described earlier (Fig. 3.11). A volumetric incentive spirometer was used as it encourages an increase in lung volume and assists in muscle activation of the diaphragm and lower respiratory muscles. The participant was instructed to take a deep breath in, followed by a full exhalation. They were then instructed to hold the incentive spirometer upright in front of his or her face. They then placed their mouth over the mouthpiece of the incentive spirometer and took a slow, deep inspiration. The participant was instructed to lift the yellow ball halfway (in the smiley face area) and continue to keep the ball at that level while they tried to lift the white indicator (float) as high as possible. Thereafter the participant exhaled completely. This was repeated for 10 repetitions and three sets. These exercises were done twice a day from the first follow-up after hospital discharge to the two-month follow-up and thereafter once daily, five days a week. After the two-month follow-up the participant was advised to increase the number of repetitions to 15 per set and then to 20 repetitions per set, as able. Exercise prescription was individualised to each participant depending on what they were able to do.

Figure 3.11: Incentive Spirometer

3.10 BIAS

The bias in this study was that some of the participants were known to the researcher and the research assistant as they were one of the treating physiotherapists during the participant's hospital stay. These participants were not treated any different during the study assessments and treatments. All physiotherapy treatment sessions and study assessment sessions were kept separate with no coaching of any participant. There was no blinding and therefore participants were aware that they were part of the study which may have caused bias. Participants may have not been completely truthful when reporting their level of pain or level of activity knowing that they were part of a study with the hopes for positive results.

3.11 STATISTICAL METHODS

Data were captured and entered on Excel spreadsheets. The IBM® Statistical Programming for the Social Sciences Statistics (SPSS) Version 23 software package was used for data analysis. Data were assessed for normality of distribution with the Shapiro Wilk test. Subsequently, continuous data such as age, hospital length of stay, EQ-5D, EQ-5D VAS, BPI, thoracic rotation ROM, IPAQ and handgrip strength were summarised as means and SD. Categorical data such as gender, type of injury and intubated or spontaneous breathing were summarised as numbers and percentages. Paired samples t-tests were used to assess changes in continuous variables over time. Level of significance was determined at $p \leq 0.05$.

In the original version of the analysis, per protocol analysis was followed. Data for those participants who dropped out at three and six months were treated as missing and data analysis was done with data for only those participants that were actively participating at all points of assessment. This approach was used to provide an estimate of the true effect of the physiotherapy intervention (Ranganathan et al., 2016).

After examination, one examiner suggested that intention-to-treat analysis be performed. This suggestion was made because of the small sample size and to eliminate bias in interpretation of the effectiveness of the physiotherapy intervention (Ranganathan et al., 2016). Here missing data at three and six months were treated as 'last observation carried forward' to the timepoints where no data was available for respective participants due to drop-out. There were no deaths in the study cohort. The data analysis presented in the amended version of the dissertation now includes intention-to-treat analysis findings. Paired samples t-tests were done, and level of significance was determined at $p \leq 0.05$.

CHAPTER 4

4. RESULTS

4.1 PARTICIPANTS

A total of 81 potential participants were identified during the study period. The flow of participant recruitment and assessment is summarised in figure 4.1.

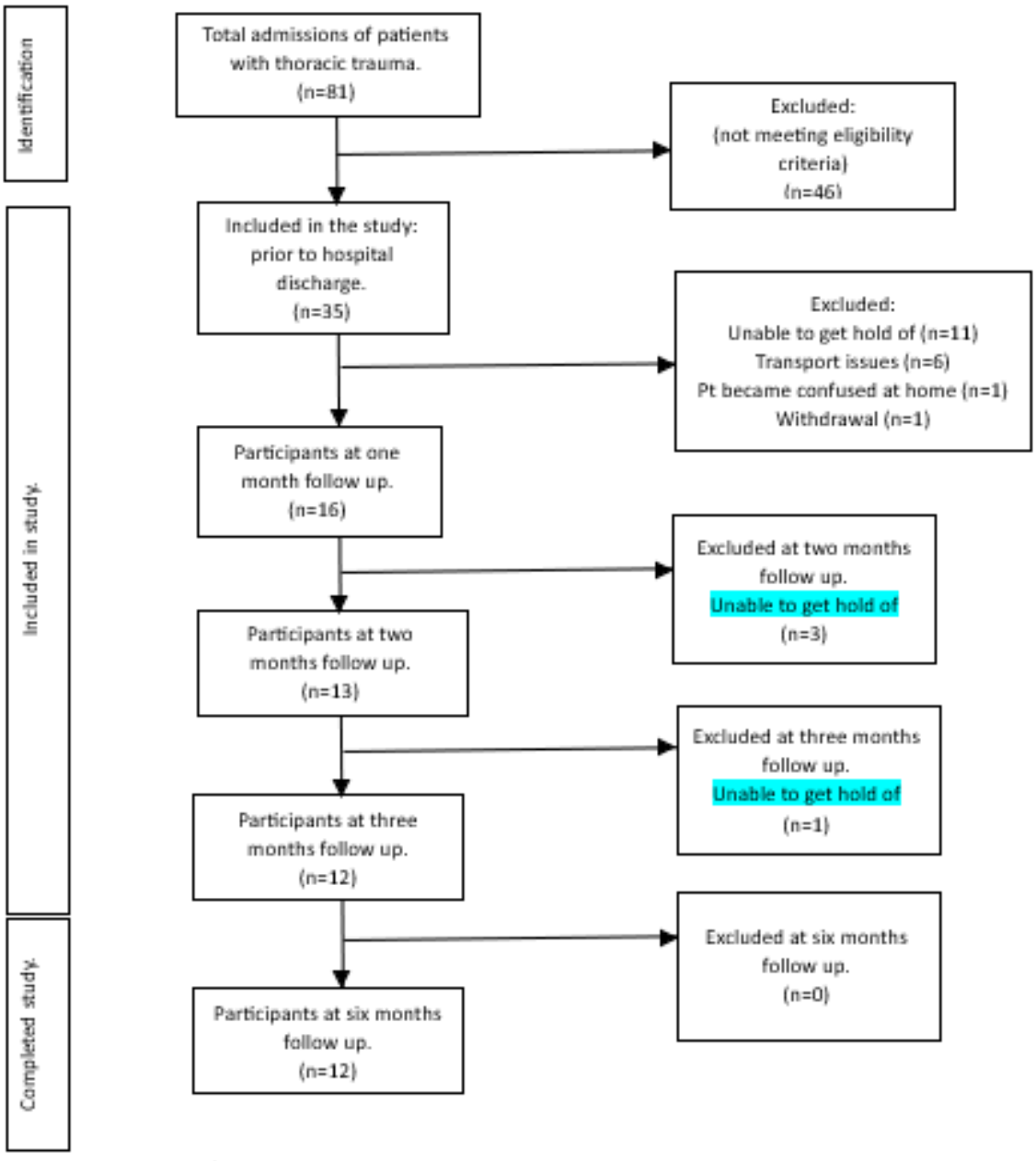

Figure: Flow of participants through the study

Figure 4.1: Flow of Participants Throughout the Study

4.1.1 Demographics and Clinical Profiles of Study Participants

4.1.1.1 Demographics and clinical profiles of study participants at hospital discharge

A total of 35 participants agreed to take part in this study and were assessed prior to hospital discharge. Of these participants, 27 (77%) were male and 8 (23%) were female. The mean age of participants was 49.3 (±15.4; range 24-89) years. The clinical profiles of participants prior to hospital discharge are summarized in table 4.1 below.

Table 4.1: The Clinical Profiles of the Study Participants prior to Hospital Discharge (n=35)

Clinical Profile	n	Percentage (%)
Diagnosis:		
Unilateral thoracic cage injury	8	21.6
Bilateral thoracic cage injury	6	16.2
Unilateral thoracic cage injury plus upper limb involvement	6	16.2
Bilateral thoracic cage injury plus upper limb involvement	3	8.1
Unilateral thoracic cage injury plus lower limb involvement	3	8.1
Bilateral thoracic cage injury plus lower limb involvement	3	8.1
Unilateral thoracic cage injury plus upper and lower limb involvement	4	10.8
Unilateral thoracic cage injury plus upper limb and spinal involvement	2	5.4
Comorbidities:		
None	24	64.9
High cholesterol	4	10.8
Previous thoracic cage injury	4	10.8
Hypertension	2	5.4
Diabetes	1	2.7
Asthma	1	2.7
Depression	1	2.7
Mechanically ventilated during hospital stay		
Yes	3	8.1
No	32	86.5

Majority of study participants sustained unilateral thoracic cage injuries (22%). As per the definition of major thoracic trauma used in this study, these patients had three or more rib fractures. Two participants had unilateral thoracic cage injuries with upper limb and spinal involvement. The spinal involvement included stable spinal fractures specifically less than three transverse process fractures. Therefore, the participants were included in the study. Upper limb involvement included fractures of the scapula, clavicle, humerus, ulna, radius, and metacarpals. Lower limb involvement included fractures of the pubic ramus, acetabulum, femur, tibia, and fibula.

All participants received physiotherapy treatment during their ICU and ward stay. These treatment sessions generally consisted of manual chest physiotherapy to assist in removing secretions, breathing exercises to improve lung volumes, assistance with mobilisation to a chair or walking and strengthening exercises. This is according to the

standard physiotherapy management described earlier in chapter 3. A variety of co-morbidities were reported by study participants, with the most common being high cholesterol (11%) and previous rib fractures (11%). The majority of patients reported no co-morbidities (65%). Three participants were intubated and mechanically ventilated, three were managed on room air, one was receiving oxygen via a polymask, and the remaining participants were managed with oxygen therapy via nasal cannula. Those patients that were ventilated had the longest hospital stay. The median length of stay for participants was 11 (Interquartile range 7.5-14.5) days.

4.1.1.2 Demographics and clinical profiles of study participants at four weeks after discharge

A total of 16 participants attended and were assessed at four weeks post hospital discharge. Of these participants, 14 (88%) were male and 2 (12%) were female. The mean age of participants was 49 (±11.4; range 26-65) years. The clinical profiles of these participants are summarized in table 4.2 below.

Table 4.2: The Clinical Profiles of the Study Participants at Four Weeks (n=16)

Clinical Profile	n	Percentage (%)
Diagnosis:		
Unilateral thoracic cage injury	2	12.5
Bilateral thoracic cage injury	3	18.8
Unilateral thoracic cage injury plus upper limb involvement	4	25
Bilateral thoracic cage injury plus upper limb involvement	2	12.5
Unilateral thoracic cage injury plus lower limb involvement	1	6.3
Bilateral thoracic cage injury plus lower limb involvement	0	0
Unilateral thoracic cage injury plus upper and lower limb involvement	2	12.5
Unilateral thoracic cage injury plus upper limb and spinal involvement	2	12.5
Comorbidities:		
None	9	56.3
High cholesterol	3	18.8
Previous thoracic cage injury	3	18.8
Hypertension	1	6.3
Diabetes	0	0
Asthma	0	0
Depression	0	0
Mechanically ventilated during hospital stay		
Yes	1	6.3
No	15	93.8

Nineteen participants were excluded during the period after hospital discharge to the four week follow up appointment. Eleven participants were excluded as they were unreachable, six participants had transport issues, one participant the family reported

became confused and one participant withdrew from the study as he reported that he is too busy to come, and he felt well.

At the four week follow up appointment 4 (25%) participants had sustained unilateral thoracic trauma plus upper limb involvement. No participants had sustained bilateral thoracic injuries plus lower limb involvement. Fifteen participants (94%) were not mechanically ventilated while in hospital.

4.1.1.3 Demographics and clinical profiles of study participants at eight weeks after hospital discharge

A total of 13 participants attended and were treated at eight weeks post discharge. Of these participants, 11 (85%) were male and 2 (15%) were female. The mean age of participants was 50 (±12.1; range 26-65) years. Their clinical profiles are summarised in table 4.3 below.

Table 4.3: The Clinical Profiles of the Study Participants at Eight Weeks after Hospital Discharge (n=13)

Clinical Profile	n	Percentage (%)
Diagnosis:		
Unilateral thoracic cage injury	2	15.4
Bilateral thoracic cage injury	2	15.4
Unilateral thoracic cage injury plus upper limb involvement	4	30.8
Bilateral thoracic cage injury plus upper limb involvement	2	15.4
Unilateral thoracic cage injury plus lower limb involvement	1	7.7
Bilateral thoracic cage injury plus lower limb involvement	0	0
Unilateral thoracic cage injury plus upper and lower limb involvement	2	15.4
Unilateral thoracic cage injury plus upper limb and spinal involvement	0	0
Comorbidities:		
None	7	56.3
High cholesterol	2	18.8
Previous thoracic cage injury	3	18.8
Hypertension	1	6.3
Diabetes	0	0
Asthma	0	0
Depression	0	0
Mechanically ventilated during hospital stay		
Yes	1	7.7
No	12	92.3

Three participants were excluded from the study between the four week follow up and the eight week follow up. These participants were excluded as they did not attend their follow up and were unreachable telephonically. At the eight week follow up, there were no participants that sustained bilateral thoracic injuries plus lower limb involvement as well as unilateral thoracic injuries plus upper limb and spinal involvement.

4.1.1.4 Demographics and clinical profiles of study participants at twelve weeks and 6 months after discharge

A total of 12 participants attended and were treated at twelve weeks post discharge and were assessed at six months. Of these participants, 10 (83%) were male and 2 (17%) were female. The mean age of participants was 50 (±12.3; range 26-65) years. Their clinical profiles are summarized in table 4.4 below.

Table 4.4: The Clinical Profiles of the Study Participants at Twelve Weeks Post Hospital Discharge

Clinical Profile	n	Percentage (%)
Diagnosis:		
Unilateral thoracic cage injury	2	16.7
Bilateral thoracic cage injury	2	16.7
Unilateral thoracic cage injury plus upper limb involvement	4	33.3
Bilateral thoracic cage injury plus upper limb involvement	2	16.7
Unilateral thoracic cage injury plus lower limb involvement	1	8.3
Bilateral thoracic cage injury plus lower limb involvement	0	0
Unilateral thoracic cage injury plus upper and lower limb involvement	1	8.3
Unilateral thoracic cage injury plus upper limb and spinal involvement	0	0
Comorbidities:		
None	6	50
High cholesterol	2	16.7
Previous thoracic cage injury	3	25
Hypertension	1	8.3
Diabetes	0	0
Asthma	0	0
Depression	0	0
Mechanically ventilated during hospital stay		
Yes	1	8.3
No	11	91.7

One participant was excluded from the study between the eight week follow up and the twelve week follow up. This participant was excluded as they did not attend their follow up and were unreachable telephonically. At twelve weeks and six months post discharge, six (50%) had no co-morbidities and three (25%) had previous thoracic injuries. Only one participant (8%) was mechanically ventilated whilst in hospital.

4.2 OUTCOMES OF PARTICIPANTS PRE AND POST INTERVENTION

4.2.1.1 The Effect of Myofascial Release and Active Exercises on the Level of Pain Experienced over Six Months using the per-protocol analysis.

Pain was assessed at one, three and six months after hospital discharge using the BPI questionnaire and the EQ-5D VAS. The participants' recalled pre-injury EQ-5D VAS was also assessed prior to discharge. At the one-month follow-up, 88% of participants reported thoracic pain as compared to 50% at the three-month follow-up. This further decreased to eight percent at the six-month post discharge follow-up.

All 35 participants that were recruited were given analgesics on discharge. Eighty-one percent of participants (n=13) were taking analgesics at the one-month post discharge follow-up. Thirty-three percent of participants (n=4) were taking analgesics at the three-month post discharge follow-up and at the six-month follow-up there were no participants taking analgesics.

Table 4.5 summarizes the levels of pain experienced by 16 participants at one month and 12 participants at three months after discharge using the BPI questionnaire.

Table 4.5: Changes in Levels of Pain Experienced by Participants between One and Three Months after Hospital Discharge Measured with the BPI Questionnaire

BPI Domains	**One Month after Discharge (n=16)**	**Three Months after Discharge (n=12)**	**One to Three Months after Discharge**		
	Mean (±SD)		*Differences in mean scores*	*95% CI*	*p-value*
BPI: Worst pain	6.3 (2.6)	1.8 (2.2)	4.5	2.83 – 6.01	*<.001
BPI: Least pain	1.9 (1.9)	0.4 (1)	1.5	0.30 –2.70	*0.019
BPI: Average pain	3.9 (2.3)	1.1 (1.2)	2.8	1.46 –4.21	*<.001
BPI: Pain now	3 (2.8)	1 (2)	2	0.62-3.38	*0.009
BPI: General activity	4.9 (3.9)	1.3 (2.3)	3.6	1.53-5.81	*0.003
BPI: Mood	2.9 (3)	1.8 (3)	1.1	-0.54-2.88	0.161
BPI: Walking	2 (3.3)	0.9 (2.6)	1.1	-1.87-4.03	0.058
BPI: Normal work	5.1 (4.2)	1 (1.7)	4.1	2.03-6.14	*0.001
BPI: Relationships	1.3 (2.8)	0 (0)	1.3	-0.55-3.05	0.115
BPI: Sleep	6.4 (3.5)	2.6 (3.8)	3.8	1.51-6.16	*0.004

BPI: Enjoyment of life	3.4 (4.1)	0.9 (1.6)	2.5	0.24-4.76	*0.033

*Indicates statistical significance

Table 4.6 summarizes the level of pain experienced by 16 participants at one month and 12 participants at six months using the BPI questionnaire.

Table 4.6: Changes in Level of Pain Experienced by Participants from One to Six Months after Hospital Discharge Measured with the BPI Questionnaire.

BPI Domains	One Month after Discharge (n=16)	Six Months after Discharge (n=12)	One to Six Months after Discharge		
	Mean (±SD)		*Differences in mean scores*	*95% CI*	*p-value*
BPI: Worst pain	6.3 (2.6)	0.2 (0.6)	6.1	4.32 – 7.85	*<.001
BPI: Least pain	1.9 (1.9)	0 (0)	1.9	0.72 – 3.11	*0.005
BPI: Average pain	3.9 (2.3)	0.1 (0.3)	3.8	2.40 – 5.26	*<.001
BPI: Pain now	3 (2.8)	0.1 (0.3)	2.9	1.11 – 4.72	*0.005
BPI: General activity	4.9 (3.9)	0 (0)	4.9	2.44 – 7.39	*0.001
BPI: Mood	2.9 (3)	0 (0)	2.9	1.03 – 4.80	*0.006
BPI: Walking	2 (3.3)	0 (0)	2	-0.08 – 4.08	*0.001
BPI: Normal work	5.1 (4.2)	0.1 (0.3)	5	2.28 – 7.72	*0.002
BPI: Relationships	1.3 (2.8)	0 (0)	1.3	-0.55 – 3.05	0.155
BPI: Sleep	6.4 (3.5)	0 (0)	6.4	4.18 – 8.66	*<.001
BPI: Enjoyment of life	3.4 (4.1)	0 (0)	3.4	0.83 – 6.01	*0.014

The changes in worst pain, least pain, average pain and the current pain experienced by participants were all statistically significant ($p<0.05$) from one to three months as well as one to six months after discharge from hospital. The BPI reports on how pain influences certain activities. Pain limited participants' general activity, normal work, sleep, and enjoyment of life significantly less from one to three months and one to six months. Similarly, it had significantly less impact on participants' mood and walking ability from one to six months post discharge from hospital ($p<0.05$).

Figure 4.2 summarises the EQ5D VAS scale results over the six months.

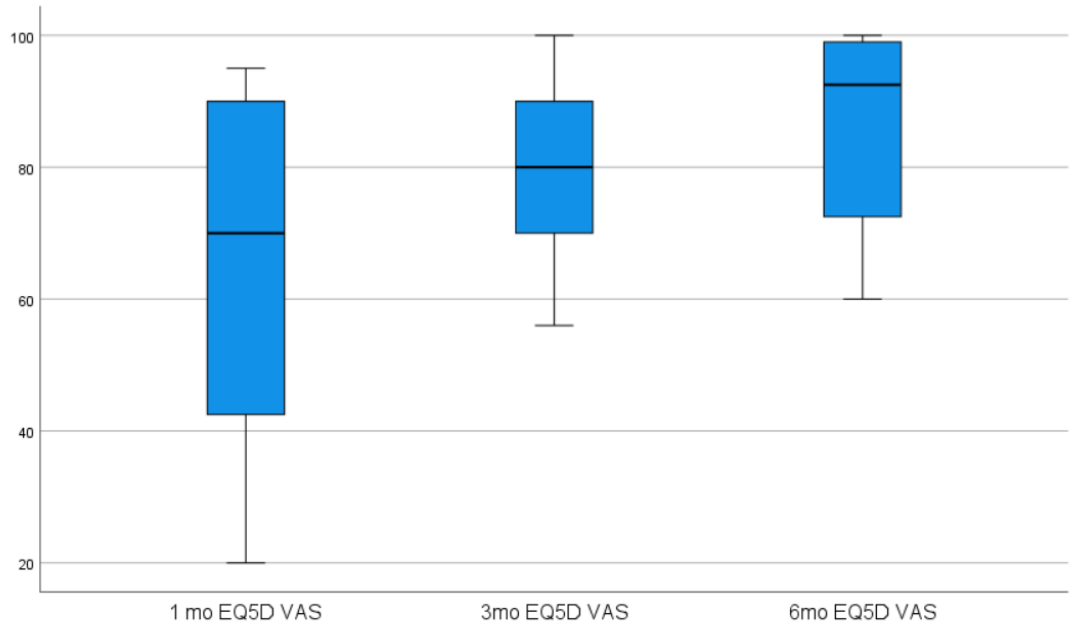

Figure 4.2: Changes in Pain Experienced by Participants as Reported with the EQ-5D VAS

The change in the mean EQ-5D VAS score from one month to three months was 13.4 which was not statistically significant (p=0.062). The change in the mean EQ-5D VAS score from one month to six months was 19.4. This change was statistically significant (p=0.023). The mean pre-injury EQ-5D VAS was 84.2 as compared to the six-month EQ-5D VAS of 85.7. The participants therefore returned to their pre-injury EQ-5D VAS.

4.2.1.2 **The Effect of Myofascial Release and Active Exercises on the Level of Pain Experienced over Six Months using the intention to treat analysis.**

Pain was assessed at one, three and six months after hospital discharge using the BPI questionnaire and the EQ-5D VAS. The participants' recalled pre-injury EQ-5D VAS was also assessed prior to discharge. At the one-month follow-up, 88% of participants reported thoracic pain as compared to 56% at the three-month follow-up. This further decreased to 25% at the six-month post discharge follow-up.

All 35 participants that were recruited were given analgesics on discharge. Eighty-one percent of participants (n=13) were taking analgesics at the one-month post discharge follow-up. Fifty percent of participants (n=8) were taking analgesics at the three-month

post discharge follow-up and at the six-month follow-up there were twenty-five percent (n=4) taking analgesics.

Table 4.7 summarizes the levels of pain experienced by 16 participants at one and three months after discharge using the BPI questionnaire using the intention to treat analysis.

Table 4.7: Changes in Levels of Pain Experienced by Participants between One and Three Months after Hospital Discharge Measured with the BPI Questionnaire

BPI Domains	One Month after Discharge (n=16)	Three Months after Discharge (n=16)	One to Three Months after Discharge		
	Mean (±SD)		*Differences in mean scores*	*95% CI*	*p-value*
BPI: Worst pain	5.8 (2.8)	3.6 (2.7)	2.2	0.703 – 3.672	0.055
BPI: Least pain	2 (2.1)	1.3 (1.9)	0.7	-0.09 –1.59	*0.003
BPI: Average pain	3.8 (2.3)	2.5 (2.2)	1.3	0.31 –2.32	*0.006
BPI: Pain now	2.9 (2.7)	1.9 (2.4)	1	0.06-1.94	*0.001
BPI: General activity	4.3 (3.8)	2.6 (3.1)	1.7	0.30-3.20	*0.002
BPI: Mood	2.9 (2.9)	2.8 (3.1)	0.1	-0.57-0.70	*<0.001
BPI: Walking	1.8 (3)	1.5 (3)	0.3	-1.56-2.19	0.213
BPI: Normal work	4.8 (3.9)	2.9 (2.9)	1.9	0.42-3.45	*0.004
BPI: Relationships	1.3 (2.7)	1.2 (2.7)	0.1	-0.07-0.20	*<0.001
BPI: Sleep	6.1 (3.5)	4.6 (3.9)	1.6	0.07-2.93	*<0.001
BPI: Enjoyment of life	3.2 (3.8)	2.3 (3.1)	0.9	-0.25-2.13	*<0.001

*Indicates statistical significance

Table 4.8 summarizes the level of pain experienced by 16 participants at one month and at six months using the BPI questionnaire using the intention to treat analysis.

Table 4.8: Changes in Level of Pain Experienced by Participants from One to Six Months after Hospital Discharge Measured with the BPI Questionnaire.

BPI Domains	One Month after Discharge (n=16)	Six Months after Discharge (n=16)	One to Six Months after Discharge		
	Mean (±SD)		*Differences in mean scores*	*95% CI*	*p-value*
BPI: Worst pain	5.8 (2.8)	3.7 (2.5)	2.1	0.63 – 3.50	0.05
BPI: Least pain	2 (2.1)	1.3 (1.9)	0.7	-0.87 – 1.59	*0.003
BPI: Average pain	3.8 (2.3)	2.6 (2.1)	1.2	0.31 – 2.19	*0.003
BPI: Pain now	2.9 (2.7)	2 (2.3)	0.9	-0.13 – 1.88	*0.001
BPI: General activity	4.3 (3.8)	2.6 (3.1)	1.8	0.3 – 3.2	*0.002
BPI: Mood	2.9 (2.9)	2.8 (3.1)	0.1	-0.57 – 0.69	*<.001
BPI: Walking	1.8 (3)	1.5 (3)	0.3	-1.56 – 2.19	0.213
BPI: Normal work	4.8 (3.8)	2.9 (2.9)	1.9	0.33 – 3.41	*0.006
BPI: Relationships	1.3 (2.7)	1.2 (2.7)	0.1	-0.07 – 0.2	*<.001
BPI: Sleep	6.1 (3.5)	4.6 (3.9)	1.5	0.07 – 2.93	*<.001
BPI: Enjoyment of life	3.2 (3.8)	2.2 (3.1)	1	-0.26 – 2.13	*<.001

The changes in least pain, average pain and the current pain experienced by participants were all statistically significant ($p<0.05$) from one to three months as well as one to six months after discharge from hospital. The BPI reports on how pain influences certain activities. Pain limited participants' general activity, normal work, sleep, and enjoyment of life significantly less from one to three months and one to six months. Similarly, it had significantly less impact on participants' mood and walking ability from one to six months post discharge from hospital ($p<0.05$).

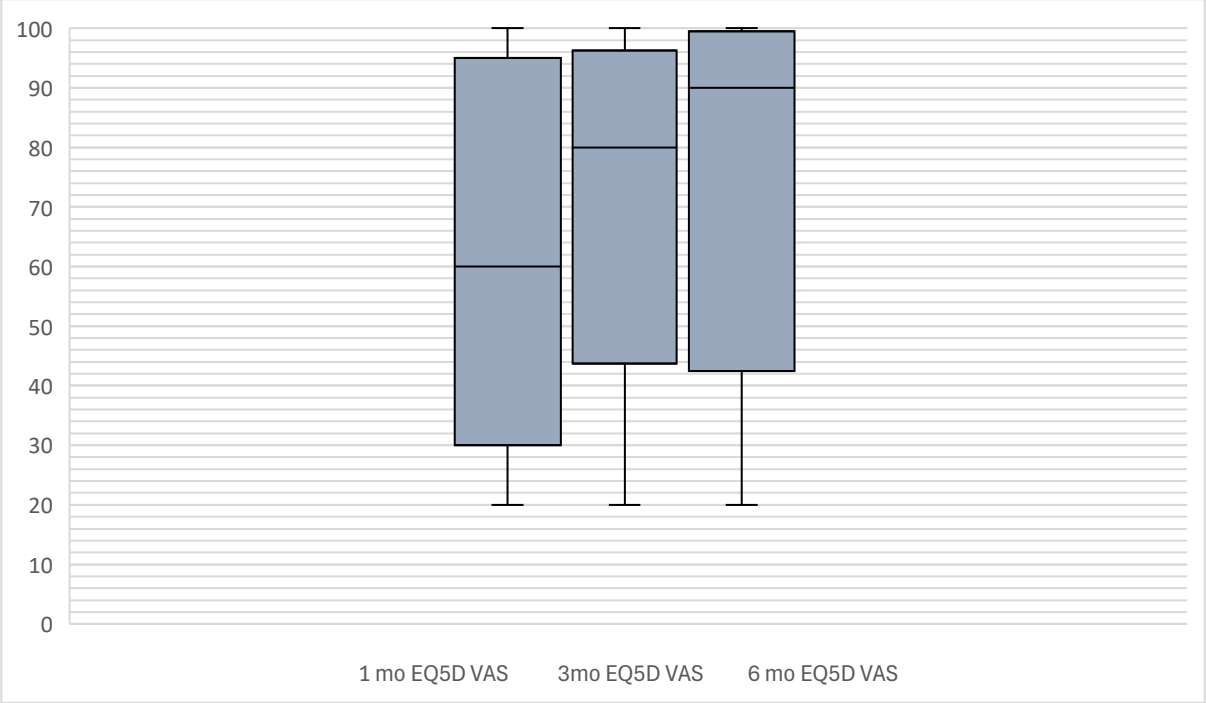

Figure 4.2 summarises the EQ5D VAS scale results over the six months.

Figure 4.2: Changes in Pain Experienced by Participants as Reported with the EQ-5D VAS

The change in the mean EQ-5D VAS score from one month to three months was 10.1 which was statistically significant (p=0.003). The change in the mean EQ-5D VAS score from one month to six months was 14.6. This change was statistically significant (p=0.021). The mean pre-injury EQ-5D VAS was 84.2 as compared to the six-month EQ-5D VAS of 81.1. The participants therefore returned to their pre-injury ED-5D VAS.

4.2.2.1 The effect of myofascial release and active exercises on respiratory outcomes and thoracic ROM using the per-protocol analysis

Respiratory outcomes such as MIP and PEFR were assessed using the POWERbreathe and peak flow meter device, respectively, at one- and three-months following discharge. Thoracic ROM was also assessed at these time points. Table 4.7 summarizes the thoracic ROM, MIP and PEFR for 16 participants at one month and 12 participants at three months.

Table 4.9: Changes in thoracic ROM, MIP and PEFR for participants over the first three months after discharge using the per-protocol analysis

Outcomes	One month after discharge (n=16) (mean, SD)		Three months after discharge (n=12) (mean, SD)		Difference in mean scores	p-value
	Right	Left	Right	Left		
Thoracic ROM (degrees)	34.9 (13.2)	35.1 (12.2)	46.2 (11.9)	45 (14.9)	Left: 11.3 Right: 9.9	*0.001 *0.004
MIP (cmH20)	83.4 (29)		97.6 (38)		14.2	*0.004
PEFR (L/min)	467.5 (127.5)		500.8 (136.2)		33.3	*<0.001

*Indicates statistical significance

The changes in thoracic ROM to both sides from one month to three months were statistically significant (p=0.001 and p=0.004, respectively). MIP and PEFR also showed statistically significant changes from one month to three months with p-values of 0.004 and <0.001 respectively.

4.2.2.2 The Effect of Myofascial Release and Active Exercises on Respiratory Outcomes and Thoracic ROM using the intention to treat analysis

Respiratory outcomes such as MIP and PEFR were assessed using the POWERbreathe and peak flow meter device, respectively, at one- and three-months following discharge. Thoracic ROM was also assessed at these time points. Table 4.7 summarizes the thoracic ROM, MIP and PEFR for 16 participants at one month and three months post discharge.

Table 4.10: Changes in Thoracic ROM, MIP and PEFR for Participants over the First Three Months after Discharge using the intention to treat analysis

Outcomes	One month after discharge (n=16) (mean, SD)		Three months after discharge (n=16) (mean, SD)		Difference in mean scores	p-value
	Right	Left	Right	Left		
Thoracic ROM (degrees)	31.3 (13.2)	31.5 (13.1)	39.7 (15.6)	38.9 (17.4)	Left: 7.4 Right: 8.4	*<0.001 *<0.001
MIP (cmH20)	82.7 (26.9)		92.6 (34.9)		9.9	*<0.001
PEFR (L/min)	435.3 (125.9)		460.3 (139.6)		25	*<0.001

*Indicates statistical significance

The changes in thoracic ROM to both sides from one month to three months were statistically significant ($p<0.001$). MIP and PEFR also showed statistically significant changes from one month to three months with p-values of <0.001.

4.2.3.1 The effect of myofascial release and active exercises on grip strength and physical function over six months using the per-protocol analysis

Grip strength was assessed with a handheld dynamometer at one month and three months after discharge. Physical function was assessed with the IPAQ questionnaire at one month, three months and six months after discharge.

Table 4.11 summarizes the handheld dynamometry results for 16 participants at one month and 12 participants at three months using the per-protocol analysis

Table 4.11: Changes in hand grip strength over the first three months following hospital discharge.

Outcome	One month post discharge (n=16) (mean, SD)		Three months post discharge (n=12) (mean, SD)		Differences in mean scores	p-value
	Right	Left	Right	Left		
Handheld dynamometry (kg) (mean, SD)	32.3 (20.9)	28.3 (17.4)	33.2 (17)	31.5 (17.5)	Right: 0.9 Left: 3.2	*<0.001 *<0.001

*Indicates statistical significance

The change in mean handgrip strength using a handheld dynamometer from one month to six months was statistically significant with a p-value of <0.001 for both the right and left hands.

Table 4.12 shows the number and percentage of participants involved in physical activity (MET min/week) as assessed with the IPAQ

Table 4.12: Level of physical activity over the first six months after hospital discharge.

MET min/week	One month (n=13) (n, %)	Three months (n=11) (n, %)	Six months (n=12) (n, %)
<600	4 (33)	4 (33)	0
600-1499	3 (25)	5 (42)	2 (17)
1500-2999	2 (17)	1 (8)	3 (25)
>2999	4 (33)	1 (8)	7 (58)

The IPAQ results were classified into the standard four different categories using the metabolic equivalent of task minutes per week (MET min/week). Less than 600 MET min/week is classified as insufficient physical activity, 600-1499 MET min/week is sufficient, 1500-2999 and greater than 2999 MET min/week is classified as high activity. Results show that at the six month follow up 83% (n=10) fell in the high activity category compared to 50% (n=6) at the one month follow up. Participants that reported less physical activity from one month to three months gave a reason that they had returned to work and therefore had less time to exercise. Majority of participants went back to work after the one month follow up which in some cases led to less physical activity and longer hours of sitting.

4.2.3.2 The Effect of Myofascial Release and Active Exercises on Grip Strength and Physical Function Over Six Months using the intention to treat analysis

Grip strength was assessed with a handheld dynamometer at one month and three months after discharge. Physical function was assessed with the IPAQ questionnaire at one month, three months and six months after discharge.

Table 4.13 summarizes the handheld dynamometry results for 16 participants at one month and at three months post discharge using the intention to treat analysis

Table 4.13: Changes in Hand Grip Strength over the First Three Months following Hospital Discharge

Outcome	One month post discharge (n=16) (mean, SD)		Three months post discharge (n=12) (mean, SD)		Differences in mean scores	p-value
	Right	Left	Right	Left		
Handheld dynamometry (kg) (mean, SD)	32.4 (19.5)	28.5 (15.9)	33.1 (16.5)	31 (16)	Right: 0.7 Left: 2.5	*<0.001 *<0.001

*Indicates statistical significance

The change in mean handgrip strength using a handheld dynamometer from one month to six months was statistically significant with a p-value of <0.001 for both the right and left hands.

Table 4.14 shows the number and percentage of participants involved in physical activity (MET min/week) as assessed with the IPAQ using the last observation carried forward

Table 4.14: Level of Physical Activity over the First Six Months after Hospital Discharge

MET min/week	One month (n=16) (n, %)	Three months (n=16) (n, %)	Six months (n=16) (n, %)
<600	7 (44)	9 (56)	4 (25)
600-1499	3 (19)	5 (31)	2 (12)
1500-2999	2 (12)	1 (6)	3 (19)
>2999	4 (25)	1 (6)	7 (44)

The IPAQ results were classified into the standard four different categories using the metabolic equivalent of task minutes per week (MET min/week). Less than 600 MET min/week is classified as insufficient physical activity, 600-1499 MET min/week is sufficient, 1500-2999 and greater than 2999 MET min/week is classified as high activity. Results show that at the six month follow up 63% (n=10) fell in the high activity category compared to 38% (n=6) at the one month follow up. Participants that reported less physical activity from one month to three months gave a reason that they had returned to work and therefore had less time to exercise. Majority of participants went

back to work after the one month follow up which in some cases led to less physical activity and longer hours of sitting.

4.2.4.1 The effect of myofascial release and active exercises on quality of life over six months using the per-protocol analysis

The EQ-5D consists of five domains including mobility, self-care, usual activities, pain and/or discomfort, and anxiety or depression. Of the 35 participants recruited for the study, 16 completed the EQ-5D at one month and 12 at three- and six months. The participants' recalled pre-injury EQ-5D results showed 23 participants (66%) reported no problems on the EQ-5D. Eight participants (23%) reported some level of depression and anxiety prior to hospital admission. Three participants (9%) reported pain or discomfort; two participants (6%) reported problems with self-care and mobility; and lastly one participant (3%) reported problems with their usual activities prior to the injury.

At one month after discharge, 11 (69%) reported that they have no problems walking about. Two (13%) reported to have slight problems when walking about. One (6%) reported to have moderate problems walking about and two participants (13%) had severe problems walking about at one month after hospital discharge. At three months following discharge, nine participants (75%) had no problems walking about and three (25%) had slight problems walking about. All twelve participants (100%) that completed the EQ-5D at six months reported no problems in walking about.

The second component on the EQ-5D is QOL in relation to self-care. At one month after hospital discharge, five participants (31%) reported to have no problems with self-care, seven (44%) had slight problems with self-care and four participants (25%) had moderate problems with self-care. At three months following discharge, nine participants (75%) had no problems with self-care and three participants (25%) had slight problems with self-care. All 12 participants (100%) that completed the EQ-5D had no problems with self-care at six months.

The third component of the EQ-5D is QOL in relation to performing usual activities (Fig. 4.3).

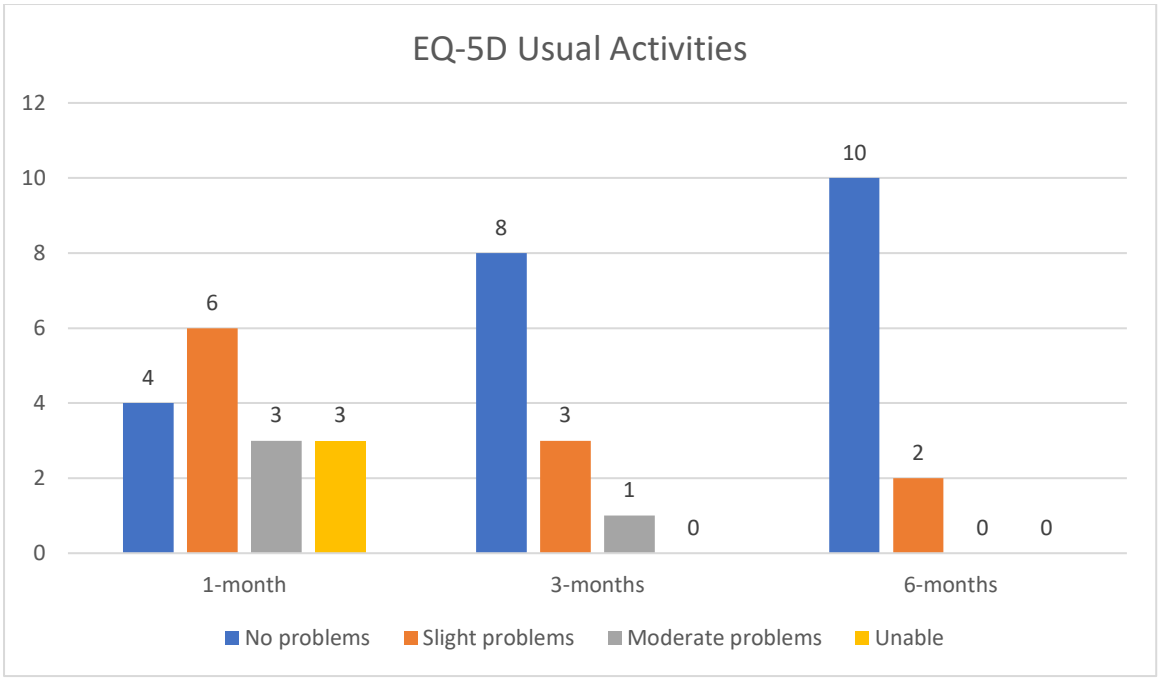

Fig. 4.3: Changes in participants' QOL in relation to their ability to perform usual activities from one to six months using the per-protocol analysis

At one month most participants reported slight problems when performing usual activities. By six months after hospital discharge, 10 participants (83%) had no problems and two participants (17%) had slight problems with their usual activities.

The fourth component of the EQ-5D is QOL in relation to pain or discomfort (Fig. 4.4).

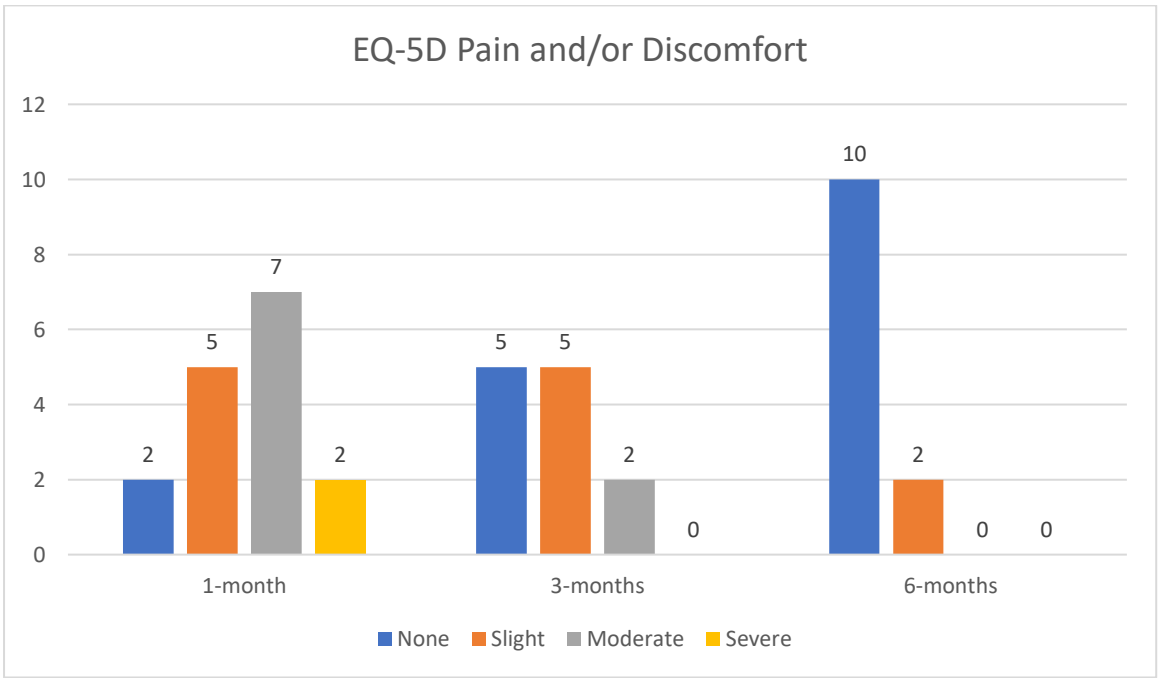

Fig. 4.4: Participants' QOL in relation to pain and/or discomfort experienced during the first six month after major thoracic trauma using the per-protocol analysis

At one month after hospital discharge, most participants reported moderate pain and/or discomfort. By six months, 10 participants (83%) had no pain or discomfort and two participants (17%) had slight pain or discomfort.

The last component of the EQ-5D is QOL in relation to anxiety and/or depression. At one month after discharge, 11 participants (69%) had no anxiety or depression, three (8%) had slight anxiety or depression, one (6%) had moderate anxiety or depression and one (6%) had severe anxiety or depression. At three- and six months following discharge from hospital, 10 participants (83%) had no anxiety or depression and two (17%) had slight anxiety or depression.

4.2.4.2 **The Effect of Myofascial Release and Active Exercises on Health-Related Quality of Life over Six Months using the intention to treat analysis**

The EQ-5D consists of five domains including mobility, self-care, usual activities, pain and/or discomfort, and anxiety or depression. Of the 35 participants recruited for the study, 16 completed the EQ-5D at one month and 12 at three- and six months. The participants' recalled pre-injury EQ-5D results showed 23 participants (66%) reported no problems on the EQ-5D. Eight participants (23%) reported some level of depression and anxiety prior to hospital admission. Three participants (9%) reported pain or discomfort; two participants (6%) reported problems with self-care and mobility; and lastly one participant (3%) reported problems with their usual activities prior to the injury.

At one month after discharge, 11 (69%) reported that they have no problems walking about. Two (13%) reported to have slight problems when walking about. One (6%) reported to have moderate problems walking about and two participants (13%) had severe problems walking about at one month after hospital discharge. At three months following discharge, eleven participants (69%) had no problems walking about, four (25%) had slight problems walking about and one participant (6%) had severe problems walking about. Fourteen participants (88%) that completed the EQ-5D at six months reported no problems in walking about, one participant (6%) reported slight problems and one participant (6%) reported severe problems when walking about.

The second component on the EQ-5D is HRQOL in relation to self-care. At one month after hospital discharge, five participants (31%) reported to have no problems with self-care, seven (44%) had slight problems with self-care and four participants (25%) had moderate problems with self-care. At three months following discharge, ten participants (63%) had no problems with self-care, five participants (31%) had slight problems and one participant (6%) had moderate problems with self-care. Thirteen participants (81%) that completed the EQ-5D had no problems with self-care at six months, two participants (13%) had slight problems and one participant had moderate problems with self-care.

The third component of the EQ-5D is HRQOL in relation to performing usual activities (Fig. 4.5).

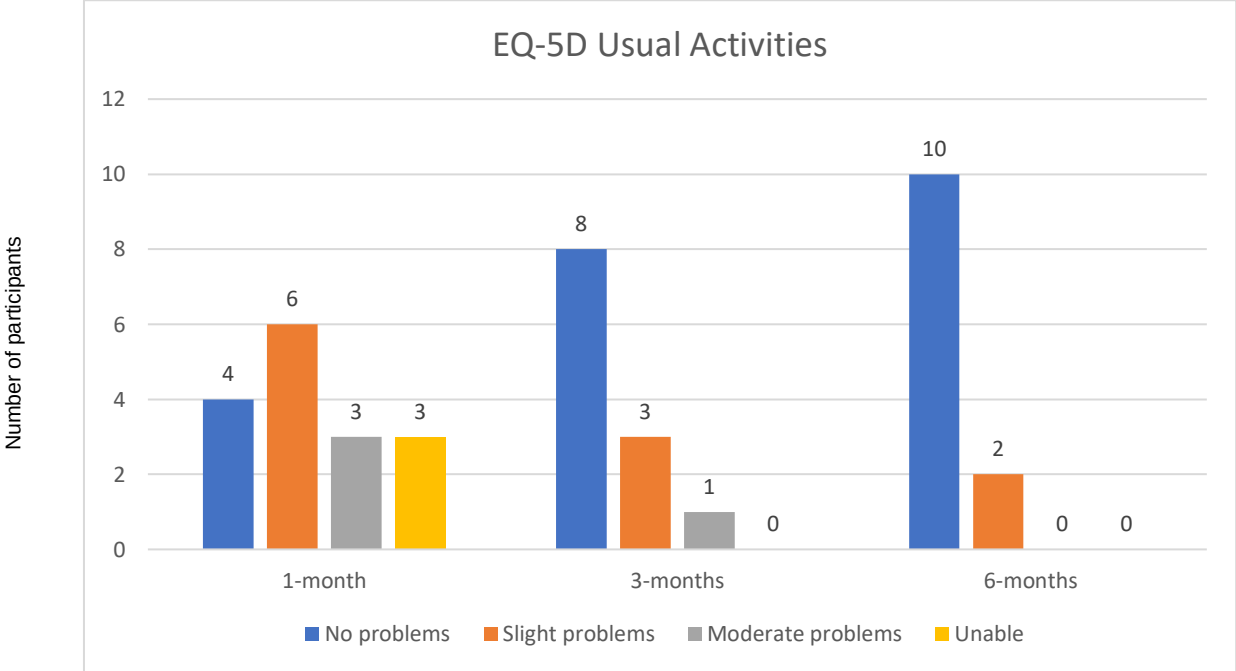

Figure 4.5: Changes in Participants' QOL in Relation to their Ability to Perform Usual Activities from One to Six Months using the intention to treat analysis

At one month most participants reported slight problems when performing usual activities. By six months after hospital discharge, 12 participants (75%) had no problems and four participants (25%) had slight problems with their usual activities.

The fourth component of the EQ-5D is HRQOL in relation to pain or discomfort (Fig. 4.6).

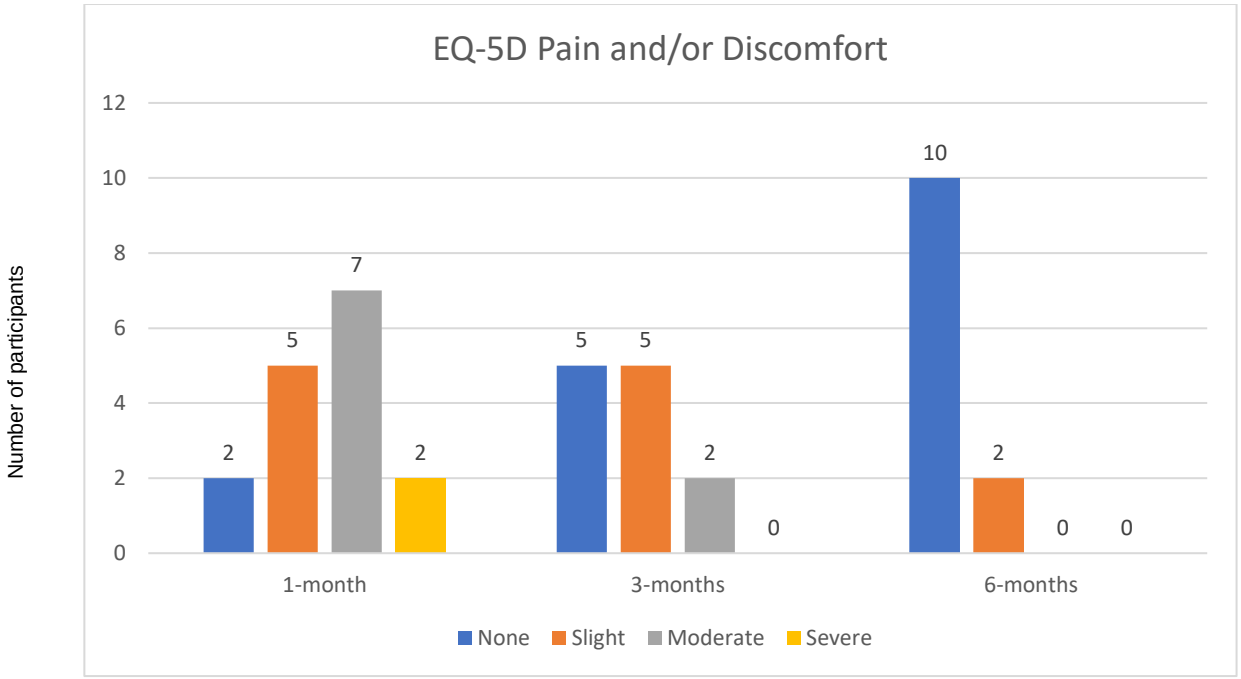

Figure 4.6: Participants' QOL in Relation to Pain and/or Discomfort Experienced during the First Six Month after Major Thoracic Trauma using the intention to treat analysis

At one month after hospital discharge, most participants reported moderate pain and/or discomfort. By six months, 11 participants (69%) had no pain or discomfort, two participants (13%) had slight pain or discomfort and three participants had moderate pain or discomfort.

The last component of the EQ-5D is HRQOL in relation to anxiety and/or depression. At one month after discharge, 11 participants (69%) had no anxiety or depression, three (8%) had slight anxiety or depression, one (6%) had moderate anxiety or depression and one (6%) had severe anxiety or depression. At three- and six months following discharge from hospital, 12 participants (75%) had no anxiety or depression, three (19%) had slight anxiety or depression and one (6%) had moderate anxiety or depression.

In the next chapter, the results obtained from this study are discussed and compared to findings reported by other researchers. Limitations to the study and recommendations from the results obtained are outlined.

CHAPTER 5

5. DISCUSSION

In this study, participants who had sustained major thoracic trauma were followed up at one, three- and six-months after hospital discharge. They were assessed using the BPI, EQ-5D and IPAQ questionnaires; in addition, assessment of their MIP, PEFR and hand grip strength was made. Participants received physiotherapy intervention in an out-patient setting which consisted of ACBT, incentive spirometry, thoracic ROM exercises, heat therapy, and myofascial release and trigger point release therapy at one month, two months and three months following discharge. Majority of participants sustained unilateral thoracic cage injuries with upper limb involvement. Most participants had no co-morbidities. Only two participants that were recruited were mechanically ventilated. Thirty-five participants were recruited for the study, 16 attended the one-month post discharge follow-up and 12 participants completed up to the six-month post discharge follow-up. Results included a per-protocol analysis and an intention to treat analysis.

5.1 LEVEL OF PAIN

Overall, the participants showed an improvement in pain from discharge from hospital to the six month follow up for both the per-protocol analysis and the intention to treat analysis. These changes in pain were for all categories of the BPI, namely, worst pain, least pain, average pain and pain experienced at present. All these changes were statistically significant from one to three months and one to six months. The BPI also identified statistically significant changes for all participants for general activity, normal work, sleep, and enjoyment of life for one to three months and one to six months. Mood and walking ability categories only showed statistically significant changes from one to six months. Relationships with others showed no statistically significant improvement throughout the study. The only difference in results using the intention to treat analysis is that the worst pain category of the BPI did not show statistically significant results.

The EQ-5D VAS scale showed favourable results using both the per-protocol and intention to treat analysis. The per-protocol analysis showed from one month to six months a mean change of 19.4 which was statistically significant. The mean change from one to three months was 13.4 and was not statistically significant. The intention to treat analysis showed statistically significant changes from one to three months and one to six months. The recalled pre-injury EQ-5D VAS mean improved by 1.5 by the

six-month follow-up. This shows that some of the participants felt that their overall health had improved six months after the intervention as opposed to pre-injury. Majority of the participants also felt that their general health had improved from when the intervention commenced until their six month follow up. These results suggest that overall, the level of pain decreased following myofascial and trigger point release therapy combined with active exercises. In most cases, tissue takes four to six weeks to heal, and therefore the decrease in pain can also be ascribed to the natural healing process of tissue over time after trauma (Wallace, Basehore and Zito, 2023). The study design did not allow for a control group and therefore one cannot state with certainty that the physiotherapy intervention was the reason why these participants showed improvement in level of pain experienced. However, in saying this, available research has shown that participants following thoracic trauma do report chronic pain and thus it is reasonable to assume that the physiotherapy intervention did play some role in reducing the level of pain experienced by these participants over time (Shelat et al., 2012; Fabricant et al., 2013; Gordy at al., 2014; Kahloul et al., 2020).

On discharge from hospital, all participants received pain treatment in the form of analgesics. The high percentage of participants taking analgesics at the one-month follow-up may have masked some of the pain experienced by the participants. The decrease in percentage of participants taking analgesics from one month to three month and then to six months is clinically significant. This suggests that participants no longer required analgesics at six months post discharge because of the therapeutic effect of the myofascial release therapy on the soft tissue of the thoracic wall and its impact on the participants' perceived pain.

Shelat et al. (2012) investigated the level of chronic pain experienced by patients following traumatic rib fractures up to one year post discharge using a telephonic questionnaire. The questionnaire included the presence of pain, the severity, and the influence of the pain on their life. One hundred and two patients responded to the survey. Although the current study used the BPI questionnaire which was not used in Shelat et al.'s (2012) study, both questionnaires included presence of pain, severity of pain and whether levels of pain influenced the participants daily activities. Nineteen percent of their patients reported pain at one year post discharge and made unscheduled visits to the hospital requesting analgesia treatment (Shelat et al., 2012). At six months post discharge, eight percent of participants in the current study reported pain which is clinically lower than Shelat et al. (2012) reported. Although Shelat et al. (2012) reported analgesia use up to one year post discharge, in this study there were

no participants taking analgesics at the six-month follow-up. Thus, we can postulate that the intervention provided in this study may have had an impact on the level of pain experienced by participants and therefore analgesics were no longer needed.

Fabricant et al. (2013), also reported that 64% of their participants experienced chronic thoracic pain two months following rib fractures using the McGill Pain Questionnaire pain rating index and present pain intensity. This research shows the prevalence of chronic pain following thoracic trauma. In our study, 88% of participants had pain at one-month post discharge which is significantly higher than Fabricant et al. (2013)'s study. However, at the three-month post discharge follow-up only 50% of participants in our study reported pain which is lower than what Fabricant et al. (2013) reported. This data suggests that the intervention program in this study could have benefitted patients with regards to level of pain at a longer period of six months post discharge. Although there is no research on myofascial release following thoracic trauma, Ajimsha et al. (2014) found that myofascial release can be used to help relieve pain and improve function in a wide variety of conditions. Research shows that chronic pain is prominent in patients following rib fractures but there is little known about whether a post discharge rehabilitation program would reduce the level of pain.

This study is the first in South Africa that tested the effect of myofascial release and trigger point release therapy combined with active exercises on patient recovery over the first six months following hospital discharge. These interventions contributed to a reduction in pain levels reported by participants and may impact the prevalence of chronic pain in this patient population. The findings do need verification through further experimental clinical research.

5.2 RESPIRATORY OUTCOMES

Respiratory outcomes that were assessed included MIP and PEFR. Per-protocol analysis and intention to treat analysis was done. These outcomes were measured at one month, prior to the intervention, and again at three months, after the final intervention was done. Both MIP and PEFR showed statistically significant changes for both analyses. Participants informally reported that they found it easier at three months to inhale fully due to decreased levels of pain and decreased stiffness of the thoracic cage. Thoracic ROM changes from one month to three months where statistically significant to both sides for per-protocol analysis and intention to treat analysis. Eight of the participants reported that at the three-month assessment they felt that it was easier to rotate due to decreased level of pain in the thorax, throughout

the movement. Level of pain and stiffness of the fascia may lead to decreased thoracic movement and therefore improving the level of pain and releasing the fascia may have assisted with this improvement (El-Kady et al., 2018).

Evidence shows that rib fractures lead to decreased PEFR which is due to the patient's inability to fully expand the ribcage because of pain and fear of movement (Wu et al., 2021). Wu et al. (2021) used a portable respiratory function detector which is similar to a peak expiratory flow meter which was used in the current study. Reshmarani, Shilpa and Veena (2020) reported that the peak flow meter was as effective as the digital spirometer. Wu et al. (2021) reported that the more ribs fractured results in poorer VC, forced expiratory volume in one second and forced VC. Pain in the thoracic cage leads to poor ventilation which causes short shallow breathing (El-Kady et al., 2018). This results in shortened respiratory muscles and stiffening of the fascia. This stiffness affects the excursion of the lungs and therefore decreases the PEFR and MIP (Nagy et al., 2022). Our study used a POWERbreathe device to assess MIP which is the same outcome measure used as Nagy et al., (2022). Nagy et al. (2022) reported that diaphragm release in combination with inspiratory muscle training results in a significant improvement in MIP at six-weeks follow-up in patients post COVID-19. Nagy et al.'s (2022) study provided diaphragm release for three sessions per week for six weeks as opposed to the current study in which the participants only received the intervention once a month for three months.

Rocha et al. (2015) also reported improved sniff nasal inspiratory pressure, maximal expiratory pressure and VC using a portable manometer and an optoelectronic plethysmography and diaphragm mobility using an ultrasound machine following an intervention of diaphragm release in patients with COPD. The authors concluded that tension in the diaphragm results in a decreased ability to generate tidal volumes. Rocha et al. (2015) reported improvement in diaphragm mobility which was not statistically significant directly after the first intervention of diaphragm release. However, after the sixth session which was done two weeks later, they reported a statistically significant improvement in diaphragm mobility. Once again, the current study had a longer period between sessions as opposed to Rocha et al. (2015) and Nagy et al. (2022). However, in Nagy et al. (2022) and Rocha et al. (2015)'s studies there was no home exercise programme given whereas in the current study participants were given a home exercise programme which included ACBT, incentive spirometry and thoracic ROM exercises. This home exercise programme was given in an attempt to maintain the improved diaphragm mobility.

Diaphragm mobility was not directly assessed in the current study and therefore it cannot be confirmed that the improvement in MIP and PEFR was due to improved diaphragm mobility. The fact that the intervention included diaphragm release suggests that the participants may have had improved diaphragm mobility. This is therefore an outcome measure that can be included in future studies to determine the cause of improved MIP and PEFR.

Marizeiro et al. (2017) reported improved chest wall mobility using cirtometry in sedentary women after receiving one intervention session of myofascial release on the diaphragm. This study showed statistically significant improvement in respiratory function directly after the intervention which opposes Rocha et al. (2015) and Nagy et al. (2022) who both found significant improvement in respiratory function only after a minimum of six sessions of diaphragm release. Therefore, Marizeiro et al. (2017) supports the current study where longer periods between sessions can result in improvement in respiratory function. Cirtometry assesses the expansion of the thoracic cage whereas our study assessed the thoracic ROM (Marizeiro et al., 2017). Including cirtometry as an outcome measure could have given more insight as to whether the intervention improved thoracic expansion. Contrary to Nagy et al. (2022), Rocha et al. (2015) stated that the contractile properties of the diaphragm were not affected.

This study did show an improvement in maximal inspiratory pressure which may be due to the soft tissue techniques but may also be because of the other interventions provided such as the thoracic ROM exercises. A previous study reported that thoracic trauma results in stiffness of the thoracic cage, therefore, by releasing the soft tissue and fascia, this may have assisted in improving thoracic excursion and lung volumes (El-Kady et al., 2018).

5.3 PHYSICAL FUNCTION

Handheld dynamometry can be used to assess overall muscle strength in a patient (Mafi et al., 2012). Both the right and left handgrip strength was assessed at one month prior to intervention and at three months, following the final intervention. There was a significant improvement in handgrip strength in both hands for participants using both the per-protocol and intention to treat analysis. Participants therefore experienced an improvement in overall muscle strength at the three month follow up assessment. This study showed that participants who had a longer hospital stay presented with a lower value for the handgrip assessment. In most cases patients who spend a longer time in

hospital spend more time in bed and might have sustained a more severe injury. This results in an increase in pro-inflammatory cytokines which leads to muscle catabolism (Van Aswegen et al., 2011). This suggests that longer hospital stay leads to a higher percentage of muscle wasting and therefore decreased overall muscle strength (Van Aswegen et al., 2011).

Forty-two percent of participants who completed the current study were shown to have weakness of the upper limb that was injured or on the side of the thoracic cage that had rib fractures. Although in most cases these participants were dominant on the side of the injury, they were still stronger on the non-injured side. This shows that not only the length of hospital stay impacted the handgrip strength but also the injuries sustained to the thoracic cage and upper limb.

Physical function was assessed using the IPAQ questionnaire. At six months follow-up 83% of participants fell into the high activity category as opposed to 50% at one month using the per-protocol analysis. At six months follow-up 63% of participants fell into the high activity category as opposed to 38% at one month using the intention to treat analysis. High activity was classified as more than 1500 MET min/week. Majority of participants showed an increase in physical activity from one month follow up to six months follow up; however, there were a few that reported they were less active at three months. These participants reported that they had returned to work by three months post discharge and therefore did not have as much time to exercise. Two participants stated that work commitments did not allow time for physical activity. However, by six months the level of activity across all participants did improve. Participants reported that they developed more of a routine by six months and therefore were able to find more time for physical activity. Using the per-protocol analysis, at the one month follow-up thirty-three percent of participants reported a MET min per week score of less than 600 which can be compared to the normal South African population of forty-six percent being classified as inactive (less than 600 MET min per week) (Medical Research Council, 2006). This value did decrease at the six-month mark to zero percent being inactive, which is significantly lower than the percentage of the normal South African population being forty-six percent (Medical Research Council, 2006).Using the intention to treat analysis, at the one month follow-up forty-four percent of participants reported a MET min per week score of less than 600 which can be compared to the normal South African population of forty-six percent being classified as inactive (less than 600 MET min per week) (Medical Research Council, 2006). This value did decrease at the six-month mark to twenty-five percent

being inactive, which is almost half the percentage of the normal South African population (Medical Research Council, 2006).

Van Aswegen et al. (2011) found that patients present with impaired physical function six months following discharge from hospital after sustaining trunk trauma using the Medical Outcomes Short Form-36 questionnaire. A combination of inactivity and prolonged exposure to inflammatory cytokines may be the cause of impaired physical function (Van Aswegen et al., 2011). Baker et al. (2021) used the EQ-5D outcome measure and reported that patients following blunt thoracic trauma had poor physical function at six months post discharge from hospital. Patients had not returned to their pre-injury physical function at six months post discharge from hospital (Baker et al., 2021). Braganca et al. (2019) concluded that handheld dynamometry can be used to assess for ICU acquired weakness. Our study suggests that poor handheld dynamometry results were found in participants with more severe injuries and therefore longer hospital stay.

As previously discussed, longer hospital stay can result in increased muscle catabolism (Van Aswegen et al., 2011). This agrees with the fact that handheld dynamometry can be used to identify general muscle weakness following discharge from hospital. Available evidence shows that patients experience impaired physical function at least six months following discharge from hospital (Schneiderman, Van Aswegen and Becker, 2011; Van Aswegen et al., 2011; Baker et al., 2021). In some cases, this impairment can even persist longer than six months as Marasco et al. (2015) reported impairment in physical function for their participants up to two years post discharge.

In the current study, there was an improvement in physical function from one month post discharge from hospital until six months post discharge. It is therefore reasonable to assume that the intervention provided to the participants played a role in their improved physical function. The participants level of physical function prior to the injury was not assessed in this study and therefore it is not clear as to whether the participants returned to their pre-injury physical function level by six months after hospital discharge or not.

5.4 QUALITY OF LIFE

Lastly, HRQOL was assessed pre-discharge, at one month, three months and six months post discharge from hospital. The EQ-5D was used to assess HRQOL and a

per-protocol and intention to treat analysis was done. The current study found a reduction in problems experienced with mobility over the six-month period. Reductions were also found in problems with self-care. Participants did mention that because they had less pain, they were able to move more freely for washing and dressing. They therefore felt that pain was the reason they had difficulty with self-care at one month post discharge. Participants also found improvement in the ability to perform their usual activities which includes activities around the house and work. There were still two participants that reported slight problems with their usual activities at the six month follow up using the per-protocol analysis which may have been as a result of residual pain and muscle weakness. The intention to treat analysis reported four participants with slight problems with their usual activities at six months. These same participants did also report slight pain on the EQ-5D at the six-month follow-up using to per-protocol analysis and three participants reported moderate pain or discomfort at the six month follow-up using the intention to treat analysis. A reduction in pain and discomfort was reported over the six-month period. Lastly, fewer participants reported anxiety and depression at the six-month follow-up. Pre-injury EQ-5D VAS versus the six-month EQ-5D VAS showed that seven participants (58%) reported either the same or improved overall health.

Only one participant who completed the study reported depression on the predischarge demographic questionnaire, and this number increased to five participants (31%) having some sort of depression or anxiety at one month post discharge. This may suggest post-intensive care syndrome or post-traumatic stress disorder that these patients present with as they did not have depression or anxiety prior to being discharged from hospital. Cuthbertson et al. (2009) states that there is a presence of post-traumatic stress disorder on the Davidson Trauma Scale up to three months after being critically ill (as cited in Hofhuis et al., p.2, (2009)). Van Aswegen et al. (2011) reported that patients following trunk trauma had problems with their mental health as reported with the EQ-5D up to six months post discharge. Kim et al. (2021) used the Korean version of the Hospital Anxiety and Depression Scale to report in his study that patients with chronic pain were more likely to present with depression and therefore residual pain may have also been the reason for these patients presenting with anxiety or depression. Participants in the current study were referred to psychology if indicated. Overall, all five domains of the EQ-5D showed improvement from one month post discharge until the six month follow up and 83% of participants returned to their recalled pre-injury QOL. In contrast, multiple studies have shown that patient's HRQOL does not return to normal after six months post discharge

(Schneiderman, Van Aswegen and Becker, 2011; Van Aswegen et al., 2011; Marasco et al., 2015; Baker et al., 2021).

Baker et al. (2021) reported that patients who sustained trauma had decreased HRQOL up to six months post discharge. This included the physical and mental components of the assessment (Baker et al., 2021). Pain and efficacy of pain management is the main reason for poor reported HRQOL (Baker et al., 2021). Results may have differed from the current study as Baker et al.'s (2021) participants had a mean age of 62 years old, whereas participants in the current study had a mean age of 49 years old. This age difference suggests that the current study's participants may have recovered quicker due to them being younger.

According to Schneiderman, Van Aswegen and Becker (2011), survivors of thoracic trauma were found to have problems in all five domains of the EQ-5D at six months post discharge from hospital. Participants did not achieve optimal HRQOL in any of the domains for the Short Form-36 questionnaire either, at the six-months assessment (Schneiderman, Van Aswegen and Becker, 2011). Schneiderman, Van Aswegen and Becker's (2011) study did however only include participants who had been in ICU and ventilated for more than 24 hours, whereas the current study included patients who were admitted in the ICU as well as the ward and only three participants recruited were mechanically ventilated. Van Aswegen et al. (2011) found that patients present with impaired HRQOL on the Medical Outcomes Short Form-36 six months following discharge from hospital after sustaining trunk trauma, however, these participants were also mechanically ventilated and in ICU and are therefore difficult to compare to the current study's participants.

Marasco et al. (2015) included all patients who had sustained major trauma with multiple rib fractures and followed them up at six months, 12 months and 24 months post discharge using the Short Form-12. These participants did not only include those in ICU and had a mean age of 52 years old and are therefore more comparable to the current studies participants. Results showed that 60% of participants still reported significant functional reduction at 24 months post discharge (Marasco et al., 2015).

These studies show the severity of thoracic trauma and how it impacts a person's HRQOL in the long-term after discharge. The current study showed that majority of participants (83%) returned to their pre-injury HRQOL after six months post discharge from hospital. It can therefore be concluded that the intervention program of myofascial

release and active exercises provided to the patients might have played a role in improving their HRQOL following thoracic trauma.

5.5 SIGNIFICANCE OF THE STUDY

Long-term complications have been researched and have shown a high percentage of patients reporting chronic pain and disability up to one year post discharge after sustaining thoracic trauma (Gordy et al., 2014). Carrie et al. (2019) found that three months after sustaining rib fractures 62% of patients experience chronic pain and 57% experience disability. Evidence on the long-term complications is becoming more prevalent however, there is still a lack of research on the effects of a rehabilitation program on clinical outcomes of patients post rib fractures (Carrie et al., 2019). Battle et al. (2021) reported that there is limited research on physical rehabilitation for patients with rib fractures. They also found that majority of research focuses on physiotherapy in the acute setting and the long-term complications are often ignored. A global survey also highlighted the lack of research on longer term rehabilitation and post discharge follow-up after sustaining rib fractures (Van Aswegen et al., 2020). They also reported that there is currently no option for routine physiotherapy rehabilitation once patients are discharged from hospital after sustaining rib fractures.

To the authors' knowledge this was the first study that investigated the effects of a post discharge physiotherapy intervention of myofascial and trigger point release therapy combined with active exercises on participants' long-term outcomes. Significant improvements in levels of pain experienced, inspiratory muscle strength, peak expiratory flow, thoracic rotation ROM, hand grip strength, physical function and QOL were reported over the six months study period. The findings from this study contribute to the limited existing body of knowledge on the topic and are encouraging. Experimental clinical trials on larger patient samples recruited from multiple participating sites are required to verify the current findings.

5.6 LIMITATIONS

The high dropout rate of 54% at one month follow-up, 19% at two-month follow-up, and 8% dropout rate at three-month follow-up was a challenge. The researcher ensured that the participants' contact numbers, a family contact number, email address and physical address was obtained prior to discharge. The researcher did attempt to contact participants on numerous occasions. Participants were also reminded telephonically of their appointment the day prior and the day of their appointment. Participants were compensated for petrol money to attend all three follow-up sessions

to try limit the dropout rate due to monetary reasons. The pre-injury EQ-5D that was done on the participants required the participant to recall their HRQOL prior to the injury. The accuracy of participant recall is questioned as evidence shows that in a study of trauma patients their recalled HRQOL on the EQ-5D and EQ-5D VAS was systematically lower than their reported scores and this may have not shown accurate results (Spronk et al., 2019).

The participant's Sequential Organ Failure Assessment score was not assessed on admission to hospital as this is not part of routine patient management at the study site. This data, if available, may have provided more insight on the severity of the participant on admission. Only articles written in English were included in this study which limits the scope of research reviewed. The participants were not assessed on whether they retained the information given to them pertaining to the home exercise program. Therefore, this may have affected their compliance in performing the home exercise program and may have influenced how the participants presented at the three-month follow-up. The use of the IPAQ tool was a limitation to this study as it was not possible to obtain a total score for the items in the questionnaire due to the design of the questionnaire which made interpretation and comparison of data difficult.

The study intervention included a combination of myofascial release, trigger point release, and active exercises and therefore it is unknown whether an individual intervention or a combination of these resulted in the positive outcomes. This study did not include a control group and therefore it is unclear as to whether the intervention was the reason for the participants improvement or whether it was due to the normal healing process over time.

The last limitation was that the training diaries given to the participants were not evaluated after the study period to assess compliance to the home exercise program. Participants were asked whether they were using the training diaries and eleven of the twelve participants that completed the study reported that they were however the content of the diaries was not assessed as participants were not asked to bring the training diaries to the session.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH

It is important that there are certain controls in place to ensure the retention of recruited participants. This can be done by offering home follow-ups of participants and collecting family members' contact details prior to discharge to assist in follow-up of

participants and possibly a lower drop-out rate. Other strategies to improve participant recruitment could be the following:

- Providing weekly telephonic contact with participants between follow-up assessments.
- More study sites to recruit participants from or a longer recruitment period.
- Attention needs to be given to study recruitment processes and early detection of pitfalls to participant recruitment.

Researchers intending to use the IPAQ questionnaire may consider using an additional test to assess physical function. An example of this could be the six-minute walk test which assesses exercise endurance. Future clinical trials should include a control group to elevate the validity of findings. Future studies should include an assessment on whether the information pertaining to the home exercise program was retained. This will ensure that the compliance in performing the home exercise program is maintained.

5.8 CLINICAL RECOMMENDATIONS

Patients who have suffered thoracic trauma could benefit from being followed up by physiotherapists after discharge from hospital to identify those with limitations in function and HRQOL and a rehabilitation program consisting of myofascial release and trigger point release therapy combined with active exercises could be provided to such patients. Patients should be routinely assessed for mental health limitations by the treating physiotherapist and the necessary referrals should be made to a psychologist. The intervention chosen for this study was novel in this study population, therefore this study design was used to test whether this intervention approach had any impact on patients' clinical outcomes. Now that the effectiveness has been tested the next step would be to go forward with a randomised controlled trial to see if similar findings can be produced.

CHAPTER 6

6. CONCLUSION

This prospective, longitudinal, quasi-experimental, repeated measures study aimed to determine the outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial and trigger point release and active exercise therapy. Participants were recruited from a single trauma centre and a consecutive sampling technique was used. The null hypothesis for the study stated that adult patients recovering from major thoracic trauma do not experience a significant difference in level of pain, physical function and HRQOL over a six-month period after receiving a myofascial release and active exercise therapy programme. Based on the findings of this study, the null hypothesis is rejected.

The primary objective was to determine the outcome of this programme on the level of pain experienced by adult patients recovering from major thoracic trauma over six months. Pain was assessed using the BPI and EQ-5D VAS. Significant reductions in levels of pain were reported by these middle-aged, predominantly male participants over the six months period. This suggests that a programme of myofascial and trigger point release therapy, applied to the diaphragm and intercostal muscles of the thorax, might contribute to patient recovery in the six months after hospital discharge.

A secondary objective was to determine the outcome of a myofascial and trigger point release and active exercise therapy programme on pulmonary function and thoracic cage ROM of adult patients recovering from major thoracic trauma over six months. Pulmonary function was assessed using a POWERbreathe device to measure MIP and a peak flow meter to measure PEFR. MIP assesses the inspiratory muscle strength, specifically the diaphragm, and is an indication of pulmonary function, specifically related to forced vital capacity (Sachs, 2009). Thoracic cage ROM was assessed with a goniometer. These participants presented with significantly improved MIP and PEFR values over the six months period. There was also a significant improvement in their thoracic ROM measurement to both sides over the six months period. These findings suggest that a physiotherapy programme including myofascial and trigger point release therapy of the intercostal muscles and diaphragm and active exercises contributes to an improvement in MIP, PEFR and thoracic ROM in the six months after hospital discharge of patients after sustaining thoracic trauma.

Another secondary objective was to determine the outcome of a myofascial and trigger point release therapy, and active exercise programme on physical activity and grip strength of adult patients recovering from major thoracic trauma over six months. Physical activity was assessed using the IPAQ questionnaire and grip strength was assessed using a handheld dynamometer. These participants showed an increase in physical activity over the six-month period. The participants also presented with statistically significant improvements in grip strength over the six-month period. The findings suggest that a physiotherapy programme including myofascial and trigger point release therapy of the intercostal muscles and diaphragm and active exercises might contribute to an improvement in physical function and handgrip strength in the six months after hospital discharge in patients after sustaining thoracic trauma.

The last objective was to determine the outcome of a myofascial release and active exercise therapy programme on the HRQOL of adult patients recovering from major thoracic trauma over six months. Participants' HRQOL was assessed using the EQ-5D questionnaire. Over the six-month period, participants showed an improvement in all five domains of the EQ-5D. These findings suggest that this physiotherapy programme including myofascial and trigger point release therapy of the intercostal muscles and diaphragm and active exercises might contribute to an improvement in HRQOL in the six months after hospital discharge following thoracic trauma.

Based on the results obtained from this study, the null hypothesis is rejected. Considering the known prevalence of pain, reduced pulmonary function outcomes, decreased physical function outcomes and poor HRQOL of patients following thoracic trauma up to six months post discharge, the results of this study should be used to motivate for further investigation into a similar physiotherapy intervention programme (consisting of myofascial and trigger point release therapy combined with active exercise therapy) applied post discharge from hospital, to test its effectiveness in altering the clinical course of adults as they recover from thoracic trauma, using a larger sample size, multiple participating sites, and a randomised controlled trial design.

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APPENDIX A

- **THE UNIVERSITY OF THE WITWATERSRAND HUMAN RESEARCH ETHICS CLEARANCE CERTIFICATE**

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Ms K Blewitt

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M220225

NAME: (Principal Investigator)	Ms K Blewitt
DEPARTMENT:	School of Therapeutic Sciences Department of Physiotherapy Medical School University
PROJECT TITLE:	*The outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial realease and active exercise therapy*
DATE CONSIDERED:	2022/02/25
DECISION:	Approved unconditionally
CONDITIONS:	Previous condition (site approvals) satisfied on 2022/06/22
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor H van Aswegen
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/06/02

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **February** and therefore reports and re-certification will be due in the month of **February** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator — Date: 06/07/2022

APPENDIX B

- **NETCARE RESEARCH ETHICS COMMITTEE PERMISSION**

Netcare Hospitals Pty Ltd

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa
www.netcare.co.za

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2022-0037

Ms Kyra Blewitt

E mail: kyra.blewitt@hotmail.com

Dear Ms Blewitt

RE: THE OUTCOMES OF ADULT PATIENTS RECOVERING FROM MAJOR THORACIC TRAUMA WHO PARTICIPATED IN A PROGRAMME OF MYOFASCIAL RELEASE AND ACTIVE EXERCISE THERAPY

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at Netcare Alberton Hospital, has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the Netcare Research Operations Committee.

ii) All information regarding Netcare will be treated as legally privileged and confidential.

iii) Netcare's name will not be mentioned without written consent from the Netcare Research Operations Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) Netcare must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Netcare Research Operations Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

viii) A copy of the research report will be provided to the Netcare Research Operations Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) Netcare has the right to implement any recommendations from the research.

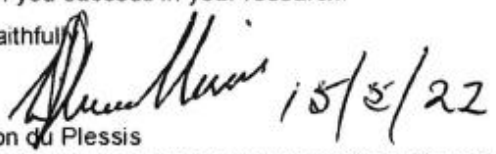
x) Netcare reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/Netcare or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

- This approval granted applies strictly to the proposal as stipulated in the original application received.
- Should any amendments or variation to the materiality of the content of the research study become necessary during the course of the study, the principal investigator/researcher must apply for approval of these amendments/changes to the Netcare Research Operations Committee, prior to implementation.
- Any extension of the duration, and / or site, and / or investigators of the authorisation granted in this approval must be applied for in writing timeously for consideration by the Netcare Research Operations Committee in order to ensure continuity of the study/research.

We wish you success in your research.

Yours faithfully



Prof Dion du Plessis
Full member: Netcare Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

03/06/2022

Dr Shannon Nell
Chairperson: Netcare Research Operations Committee
Netcare Hospitals (Pty) Ltd **Date:**

APPENDIX C

- **NETCARE ALBERTON MANAGEMENT PERMISSION**

Netcare Alberton Hospital

Tel: +27 (0) 11 724 2000
Fax: +27 (0) 11 724 2458
1 Netcare Avenue, Newmarket Precint, Alberton, South Africa
PO Box 1059, Alberton, 1450, South Africa
www.netcare.co.za

LETTER CONFIRMING KNOWLEDGE OF NON-TRIAL RESEARCH TO BE CONDUCTED IN THIS NETCARE FACILITY

Dear Kyra Blewitt

Re: The outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial release and active exercise therapy.

We hereby confirm knowledge of the above named research application to be made to the Netcare Research Operations Committee and in principle agree to the research application for Netcare Parklane Union Hospital/site/division, subject to the following:

1. That the data collection may not commence prior to receipt of FINAL APPROVAL from the Netcare Research Operations Committee.
2. A copy of the research report will be provided to the Netcare Research Operations Committee once it is finally approved by the tertiary institution, or once complete.
3. Netcare has the right to implement any recommendations from the research.
4. That the Hospital/Site/Division Management reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects / Netcare or should the researcher not comply with the conditions of approval.

We wish you success in your research.

Yours faithfully

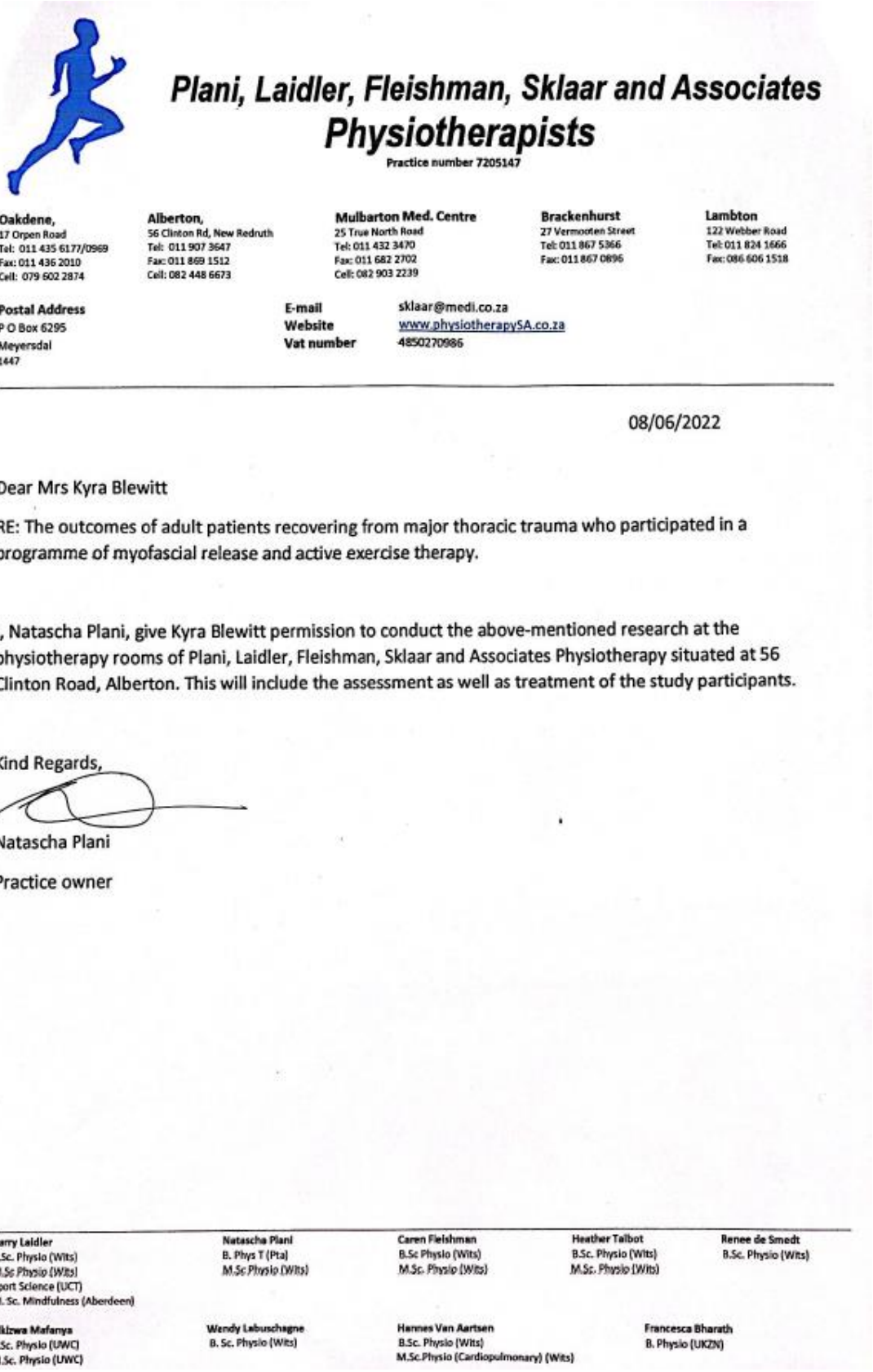
28.4.2022

Signed by Hospital/Site/Division Management **Date**

General Hospital Manager
(Acting)

APPENDIX D

- **PLANI, LAIDLER, FLEISHMAN, SKLAAR AND ASSOCIATES PRACTICE PERMISSION**



Plani, Laidler, Fleishman, Sklaar and Associates
Physiotherapists
Practice number 7205147

Oakdene,
17 Orpen Road
Tel: 011 435 6177/0969
Fax: 011 436 2010
Cell: 079 602 2874

Alberton,
56 Clinton Rd, New Redruth
Tel: 011 907 3647
Fax: 011 869 1512
Cell: 082 448 6673

Mulbarton Med. Centre
25 True North Road
Tel: 011 432 3470
Fax: 011 682 2702
Cell: 082 903 2239

Brackenhurst
27 Vermooten Street
Tel: 011 867 5366
Fax: 011 867 0896

Lambton
122 Webber Road
Tel: 011 824 1666
Fax: 086 606 1518

Postal Address
P O Box 6295
Meyersdal
1447

E-mail sklaar@medi.co.za
Website www.physiotherapySA.co.za
Vat number 4850270986

08/06/2022

Dear Mrs Kyra Blewitt

RE: The outcomes of adult patients recovering from major thoracic trauma who participated in a programme of myofascial release and active exercise therapy.

I, Natascha Plani, give Kyra Blewitt permission to conduct the above-mentioned research at the physiotherapy rooms of Plani, Laidler, Fleishman, Sklaar and Associates Physiotherapy situated at 56 Clinton Road, Alberton. This will include the assessment as well as treatment of the study participants.

Kind Regards,

Natascha Plani

Practice owner

Barry Laidler
B.Sc. Physio (Wits)
M.Sc Physio (Wits)
Sport Science (UCT)
M. Sc. Mindfulness (Aberdeen)

Natascha Plani
B. Phys T (Pta)
M.Sc Physio (Wits)

Caren Fleishman
B.Sc Physio (Wits)
M.Sc. Physio (Wits)

Heather Talbot
B.Sc. Physio (Wits)
M.Sc. Physio (Wits)

Renee de Smedt
B.Sc. Physio (Wits)

Cikizwa Mafanya
B.Sc. Physio (UWC)
M.Sc. Physio (UWC)

Wendy Labuschagne
B. Sc. Physio (Wits)

Hannes Van Aartsen
B.Sc. Physio (Wits)
M.Sc.Physio (Cardiopulmonary) (Wits)

Francesca Bharath
B. Physio (UKZN)

APPENDIX E

- **INTRODUCTION TREE CERTIFICATE**

TRREE

Zertifikat Certificado
Certificat Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Clinical Trials Centre
The University of Hong Kong

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Kyra Blewitt

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

Release Date: 2021/12/11

CID : E4AbYF6xtS

FMH Continuing Education Program (5 Credits)
Programme de Formation Continue (5 Crédits)

Fondazione Pharmaceutica Helvetiae
FPH
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European and Developing Countries Clinical Trials Partnership (EDCTP) (www.edctp.org) - Swiss National Science Foundation (www.snf.ch) - Canadian Institutes of Health Research (http://www.cihr-irsc.gc.ca/e/2589.html) - Swiss Academy of Medical Science (SAMS/ASSM/SAMW) (www.samw.ch) - Commission for Research Partnerships with Developing Countries (www.kfpe.ch)

[REV : 20170310]

APPENDIX F

- **PILOT STUDY RESULTS**

Thoracic Range of Motion Inter and Intra-rater Reliability Testing: Participant 1			
Assessor	**Testing session**	**Right (degrees)**	**Left (degrees)**
A	1	30	38
	2	30	37
	3	32	39
	Mean	31	38
B	1	28	40
	2	30	37
	3	31	42
	Mean	30	40

Thoracic Range of Motion Inter and Intra-rater Reliability Testing: Participant 2			
Assessor	**Testing session**	**Right (degrees)**	**Left (degrees)**
A	1	22	36
	2	25	40
	3	24	42
	Mean	24	39
B	1	27	43
	2	25	39
	3	25	42
	Mean	26	41

Thoracic Range of Motion Inter and Intra-rater Reliability Testing: Participant 3			
Assessor	**Testing session**	**Right (degrees)**	**Left (degrees)**
A	1	35	34
	2	33	37
	3	39	36
	Mean	36	36
B	1	44	36
	2	38	35
	3	41	33
	Mean	41	35

PILOT STUDY TWO RESULTS SUMMARY

To determine the inter-rater and intra-rater reliability of the thoracic rotation ROM assessment of the researcher and the research assistant.

Hypotheses:

- High inter-rater correlation exists for data collected during thoracic rotation ROM (to the right and left sides) between the researcher and the research assistant.
- High intra-rater correlation exists for data collected during thoracic rotation ROM (to the right and left sides) by the researcher and by the research assistant.

Method:

Thoracic rotation ROM measurements were taken by both the researcher and the research assistant on all three participants three times with a 30-minute rest between. The seated rotation test was used. The participant was seated with their hips and knees flexed at ninety degrees with a ball (21cm diameter) placed between their knees. A polyvinyl chloride pipe measuring 105cm (diameter 2.5cm) with a mark in the centre was used to standardise the position of the upper limbs. The bar was then placed in the front of the patient's chest with their arms crossed over the bar. The goniometer was placed parallel to the ground between the T1 and T2 spinous process. The spine of the scapula was used as a reference point. The stationary arm was pointed away from the rotation side and remained parallel to the starting position. The participant was instructed to maximally rotate to the side to be tested and the examiner followed the motion with the moving arm of the goniometer.

Data analysis:

Pearson correlation (r) was calculated to test inter-rater reliability between the researcher and the research assistant for measurements taken for the pilot study participants. The correlation coefficient was interpreted according to the criteria described by Cohen (1988) as 0 no association, 0.1 to 0.3 or −0.1 to −0.3 small effect. 0.3 to 0.5 or −0.3 to −0.5 medium effect, and 0.5 to 1.0 or −0.5 to −1.0 large effect. Similarly, Pearson r-value was used to test intra-rater reliability for measurements taken by the researcher and the research assistant for the pilot study participants at three different test sessions. Furthermore, an analysis of variance was used to test for any significant differences between measurements taken by the researcher at the three test sessions (for intra-rater testing) and similarly for the research assistant. The level of significance was set as p-value <0.05.

Results:

a) Inter-rater reliability:

The level of association between measurements taken by the researcher and the research assistant for thoracic rotation to the right side was high ($r=0.94$) and not significant ($p=0.08$). The level of association between measurements taken by the same testers for thoracic rotation to the left side was high ($r=0.98$) and significant ($p=0.01$). The study hypothesis can therefore be accepted for measurements taken between the researcher and research assistant for thoracic rotation to the left.

b) Intra-rater reliability:

The level of association between measurements taken by the researcher, at the three different test sessions, for thoracic rotation to the right side was high ($r=0.99$) and this was significant ($p=0.00$). There was no significant difference in measurements taken across the three test

sessions for thoracic rotation to the right (p=0.85 using ANOVA). The study hypothesis can therefore be accepted for measurements taken by the researcher for thoracic rotation to the right.

The level of association between measurements taken by the researcher for thoracic rotation to the left was moderate (r=0.5) and this was not significant (p=0.6). There was no significant difference in measurements taken across the three test sessions for thoracic rotation to the left (p=0.33 using ANOVA). The study hypothesis can therefore be rejected for measurements taken by the researcher for thoracic rotation to the left as the correlation was moderate and not high.

The level of association between measurements taken by the research assistant, at the three different test sessions, for thoracic rotation to the right side was high (r=0.95) and this was almost significant (p=0.06). There was no significant difference in measurements taken across the three test sessions for thoracic rotation to the right (p=0.95 using ANOVA). The study hypothesis can therefore be accepted for measurements taken by the research assistant for thoracic rotation to the right.

The level of association between measurements taken by the research assistant for thoracic rotation to the left was moderate (r=0.9) and this was not significant (p=0.1). There was no significant difference in measurements taken across the three test sessions for thoracic rotation to the left (p=0.55 using ANOVA). The study hypothesis can therefore be rejected for measurements taken by the research assistant for thoracic rotation to the left as the correlation was moderate and not high.

APPENDIX G

- **PARTICIPANT INFORMATION SHEET**

Research title: The outcomes of myofascial release and active exercises on level of pain, physical function and quality of life of adults recovering from major thoracic trauma.

Dear patient

I, Kyra Blewitt, am conducting research on the effect of myofascial release and active exercises on clinical outcomes of patients who have sustained thoracic trauma. I would like to invite you to take part in my research study. Before you decide, it is important that you understand why the research is being done and what it would involve for you. Please take the time to read this information and discuss it with others if you wish. If there is anything that is not clear, or if you would like more information, please ask.

What is the purpose of the study?
The purpose of this study is to find out whether an outpatient physiotherapy treatment (including myofascial release and exercises) will improve a patient's pain, physical function and quality of life following major chest injury.

Why have I been invited?
Patients who have had a trauma which has affected their chest will be asked to participate in the study. 24 participants with major chest trauma will be included in the study.

Do I have to take part?
No, taking part in the study is entirely voluntary. A participant can withdraw if he/she later changes his/her mind, without giving a reason. Withdrawal will not affect clinical care in hospital.

What will happen to me if I decide to take part?
- Completion of three questionnaires (EQ5D including VAS to assess preadmission and pre-discharge quality of life and pain, IPAQ to assess pre-discharge physical activity and Brief Pain Inventory to assess pre-discharge pain) prior to discharge.
- You will be required to attend three sessions at our physiotherapy rooms at 56 Clinton Road, Alberton.
- The first follow up (4 weeks after discharge) will include an assessment of the same three questionnaires as well as measurement of your thoracic range of motion, peak flow meter and maximal inspiratory pressures to assess respiratory function.
- The first follow up will also include a physiotherapy treatment which includes myofascial release of the muscles used for respiration, thoracic range of motion exercises and a home exercise programme including breathing exercises and the thoracic range of motion exercises.
- The second follow up (8 weeks after discharge) will include the physiotherapy treatment as explained above.
- The third follow up (12 weeks after discharge) will include the physiotherapy treatment as above followed by a reassessment of the three questionnaires, measurement of your

thoracic range of motion, peak flow meter and maximal inspiratory pressures to assess respiratory function.
- Lastly you will be contacted at 6 months after discharge for a telephonic follow up which will include the EQ5D, IPAQ and the Brief Pain Inventory Questionnaire.

Each session will take approximately one hour.

Are there any possible disadvantages or risks from taking part?
There is a possibility of the physiotherapy treatment causing some discomfort or pain. If the participant experiences any severe pain that does not subside within 24 hours the intervention will be terminated.

What are the possible benefits of taking part?
The possible benefit of your participation in this study is that the physiotherapy interventions may improve your quality of life and reduce your level of pain experienced. This study also allows you to track your own progress after hospital discharge by having standardised tests administered. You will also contribute to the data available in South Africa and this may help health care services to improve.

You will still be allowed to continue with the treatments of your choice as prescribed by your doctor, physiotherapist and/or other health care professional.

Will my taking part in the study be kept confidential?
Yes, your personal information will be kept separate from all other documentation and will be password protected.

Other important points:
- You will be given pertinent information on the study while you are involved in it and after the results of the study are available.
- Your participation in this study is voluntary. If you refuse to participate it will not involve any penalty or loss of benefits which you are otherwise entitled to. You may discontinue your participation in the study at any time without penalty or loss of benefits to which you are otherwise entitled to. You do not need to provide any reasons if you want to terminate your participation.
- You will be reimbursed for your travel expenses to attend sessions.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. This committee is to safeguard the rights and dignity of all participants who agree to participate in a research project and the integrity of the research.

For further information or reporting of study related adverse events, please contact me:
Kyra Lee Blewitt
Mobile: 084 455 0027
Tel: (011) 907 3647
E-mail: kyra.blewitt@hotmail.com

To report any complaints or problems, please contact the Human Research Ethics Committee administrator or chair:

Prof Clement Penny (Chair): Tel nr: (011) 488 3820 or email: clement.penny@wits.ac.za
Zanele Ndlovu (Administrator): Tel nr: (011) 717 2700 or email: Zanele.ndlovu@wits.ac.za

APPENDIX H

- **PARTICIPANT CONSENT FORM**

Research Title: *"The outcomes of myofascial release and active exercises on the level of pain, physical function and quality of life of adults recovering from major thoracic trauma."*

Informed consent:

- I hereby confirm that I have been informed by the researcher/ research assistant about the nature, conduct, benefits and risks of this study.
- I have received, read and understand the information document given to me explaining the research study.
- I am aware that the results of this study, including my personal details regarding my gender, age and diagnosis will be anonymously processed into a report.
- I agree that the data collected during this study can be processed in a computerised system by the researcher or research assistants on their behalf.
- I have had the opportunity to ask questions and (of my own free will) declare myself prepared to participate in this study.

Participant's name:_____ Date:_____

Participant's signature: _____ Date: _____

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

Researcher's name:_____ Date:_____

Researcher's signature: _____ Date: _____

APPENDIX I

- **DEMOGRAPHIC QUESTIONNAIRE**

Participant name :_____

Participant code :_____

Age :_____

Gender :_____

Diagnosis :_____

Previous disability or pre-morbid conditions:_____

Hospital length of stay?_____

Were you ventilated whilst in hospital or were you breathing on your own with oxygen?

_____

Physical address :_____

Telephone number :_____

Mobile number :_____

E-mail address :_____

APPENDIX J

- **EQ-5D QUESTIONNAIRE**

Health Questionnaire

English version for South Africa

Under each heading, please tick the ONE box that best describes your health TODAY.

MOBILITY

I have no problems in walking about ❑
I have slight problems in walking about ❑
I have moderate problems in walking about ❑
I have severe problems in walking about ❑
I am unable to walk about ❑

SELF-CARE

I have no problems washing or dressing myself ❑
I have slight problems washing or dressing myself ❑
I have moderate problems washing or dressing myself ❑
I have severe problems washing or dressing myself ❑
I am unable to wash or dress myself ❑

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

I have no problems doing my usual activities ❑
I have slight problems doing my usual activities ❑
I have moderate problems doing my usual activities ❑
I have severe problems doing my usual activities ❑
I am unable to do my usual activities ❑

PAIN / DISCOMFORT

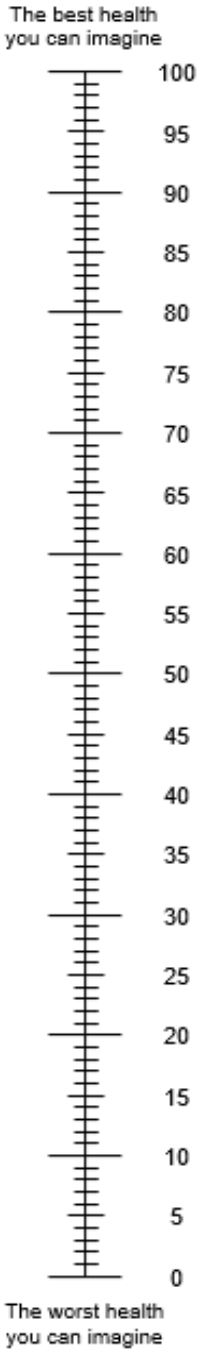
I have no pain or discomfort ❑
I have slight pain or discomfort ❑
I have moderate pain or discomfort ❑
I have severe pain or discomfort ❑
I have extreme pain or discomfort ❑

ANXIETY / DEPRESSION

I am not anxious or depressed ❑
I am slightly anxious or depressed ❑
I am moderately anxious or depressed ❑
I am severely anxious or depressed ❑
I am extremely anxious or depressed ❑

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.

YOUR HEALTH TODAY = ☐



APPENDIX K

- **BRIEF PAIN INVENTORY QUESTIONNAIRE**

1903

Date: (month) / (day) / (year)

Subject's Initials : _____

Study Subject #:

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

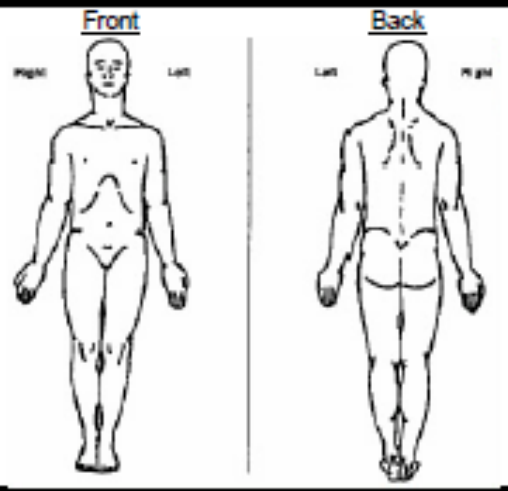
PLEASE USE BLACK INK PEN

Brief Pain Inventory (Short Form)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain today?

☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.



3. Please rate your pain by marking the box beside the number that best describes your pain at its worst in the last 24 hours.

☐ 0 No Pain ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Pain As Bad As You Can Imagine

4. Please rate your pain by marking the box beside the number that best describes your pain at its least in the last 24 hours.

☐ 0 No Pain ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Pain As Bad As You Can Imagine

5. Please rate your pain by marking the box beside the number that best describes your pain on the average.

☐ 0 No Pain ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Pain As Bad As You Can Imagine

6. Please rate your pain by marking the box beside the number that tells how much pain you have right now.

☐ 0 No Pain ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 Pain As Bad As You Can Imagine

Page 1 of 2

1903

Date: ☐☐ / ☐☐ / ☐☐
(month) (day) (year)

Subject's Initials : _____

Study Subject #: ☐☐☐☐

Study Name: _____

Protocol #: _____

PI: _____

Revision: 07/01/05

PLEASE USE BLACK INK PEN

7. What treatments or medications are you receiving for your pain?

8. In the last 24 hours, how much relief have pain treatments or medications provided? Please mark the box below the percentage that most shows how much relief you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
☐ No Relief	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐ Complete Relief

9. Mark the box beside the number that describes how, during the past 24 hours, pain has interfered with your:

A. General Activity

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

B. Mood

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

C. Walking ability

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

D. Normal Work (includes both work outside the home and housework)

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

E. Relations with other people

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

F. Sleep

☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

G. Enjoyment of life

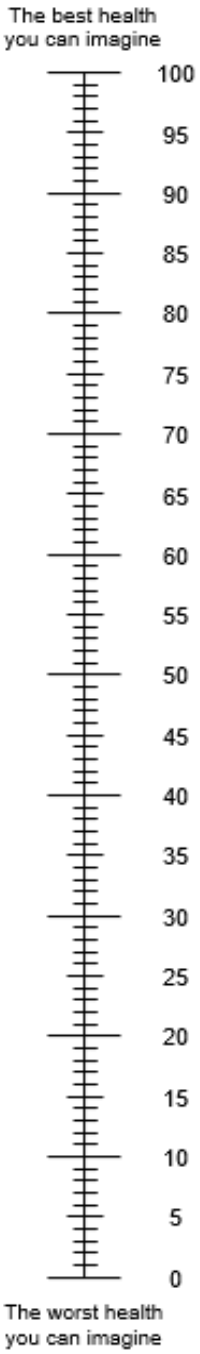
☐0 Does Not Interfere ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 Completely Interferes

APPENDIX L

- **EQ-5D VAS SCALE**

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.

YOUR HEALTH TODAY = ☐



APPENDIX M

- **IPAQ QUESTIONNAIRE**

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

APPENDIX N

- **EXERCISE RECORDING SHEET**

Exercise logbook (First month):

Name:

Exercise	Date:											
	Monday		Tuesday		Wednesday		Thursday		Friday	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Thoracic ROM exercises										
Breathing exercises										
Incentive Spirometry										

Exercise logbook (After first month)

Name:

Exercise	Date:				
	Monday	Tuesday	Wednesday	Thursday	Friday
Thoracic ROM exercises					
Breathing exercises					
Incentive Spirometry					

APPENDIX O

- **DATA OUTCOME MEASURE RECORDING SHEETS**

Outcome measure recording sheet:

Patient code:_____

Assessment:	Initial assessment: Date:	Second Assessment: Date:	Comments:
Thoracic ROM	Rotation to the right:_____ Rotation to the left:	Rotation to the right:_____ Rotation to the left:	
Maximal inspiratory pressure	1st attempt:_____ 2nd attempt:_____ 3rd attempt:_____ Best value:_____	1st attempt:_____ 2nd attempt:_____ 3rd attempt:_____ Best value:_____	
Peak expiratory flow rate	1st attempt:_____ 2nd attempt:_____ 3rd attempt:_____ Best value:_____	1st attempt:_____ 2nd attempt:_____ 3rd attempt:_____ Best value:_____	
Handheld dynamometry	Right grip strength:_____ Left grip strength:	Right grip strength:_____ Left grip strength:	

APPENDIX P

- **TURN-IT-IN REPORT**

Dissertation

ORIGINALITY REPORT

18%	15%	11%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	hdl.handle.net Internet Source	2%
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8	"World Physical Therapy 2007 - Abstracts", Physiotherapy, 2007 Publication	<1%
9	Submitted to University of Witwatersrand Student Paper	<1%