THE NATURE OF INVOLVEMENT OF PHYSIOTHERAPISTS IN SOUTH AFRICA IN THE WEANING OF MECHANICALLY VENTILATED PATIENTS

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A research report submitted to the Faculty of Health Sciences, University of Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Masters of Science in Physiotherapy.
Johannesburg, 2014
DECLARATION

I, Dipna Morar, declare that this research report is my own work. It is being submitted for the degree of Masters of Science in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

31 January 2014
ABSTRACT

Introduction:
Mechanical ventilation (MV) is the defining event of intensive care unit (ICU) management. Although it is a lifesaving intervention in patients with acute respiratory failure and other diseases, a major goal of critical care clinicians should be to liberate patients from MV as early as possible to avoid the multitude of complications and risks associated with prolonged MV. Such complications include an increase in mortality, morbidity and ICU length of stay (LOS), as well as reduced functional status and quality of life (Moodie et al 2011; Gosselink et al 2008). Rapid weaning however has its own potential problems such as fatigue or cardiovascular instability, either of which may ultimately delay the weaning process. Premature extubation, leading to reintubation, is associated with increased risk of pneumonia and mortality (Brown et al 2011; Meade et al 2001 (a)). In view of this, there has been increasing interest in delivering more consistent practice in ICUs by developing weaning protocols that provide structured guidelines to achieve prompt and successful weaning. Many studies have shown the benefit of allied health care worker (nurses and physiotherapists) driven weaning protocols in decreasing MV days and costs (MacIntyre 2005; Dries et al 2004; Ely et al 2001).

Objectives:
The objectives of this study were to determine a) if the number of patients in the ICU has an influence on physiotherapists' involvement in the weaning of patients from MV, b) if the type of ICU has an influence on physiotherapists' involvement in the weaning of patients from MV, c) if physiotherapists are involved in the development and implementation of weaning protocols for mechanically ventilated patients in their ICUs, d) if physiotherapists are involved in titration of ventilator settings for patients during the weaning process, e) what modalities physiotherapists in South Africa use to facilitate respiratory muscle strengthening to assist weaning of patients on MV, f) if physiotherapists in South Africa are involved in the extubation of ventilated patients, g) if there is a difference in involvement in weaning of mechanically ventilated patients between newly qualified physiotherapists and experienced physiotherapists. The last objective of this study was to determine if current physiotherapy involvement in the weaning of patients from MV in South Africa is in line with international physiotherapy practice according to the literature.

Method:
A questionnaire was developed by the researcher using available literature on the nature of involvement of physiotherapists in the weaning of mechanically ventilated patients. Content validation of the questionnaire was achieved after a panel of senior cardiopulmonary physiotherapists analysed each question and their recommendations and adjustments were implemented. Physiotherapists who practice cardiopulmonary physiotherapy in adult ICUs of
hospitals in the public and private sectors in South Africa were sought and targeted for the study. The self-administered questionnaire was then posted or emailed to the physiotherapists identified for inclusion into the study.

Results:
A total of 425 questionnaires were distributed to physiotherapists who practice cardiopulmonary physiotherapy in adult ICUs of hospitals in South Africa. Of the 425 questionnaires distributed, 200 questionnaires were sent via the postal system and 225 were sent via email with a link to an online survey. The response rate for the postal questionnaires was 54.5% (n=109) and 33.3% (n=75) for the emailed questionnaire, giving a combined response rate of 43.3%. The results showed that 76% of South African physiotherapists are not or are seldom involved in the weaning of mechanically ventilated patients in adult ICUs. They are not involved in the development of weaning protocols (74%, n=51), titration and adjustment of MV settings (>80%, n=154), spontaneous breathing trails (67%, n=119) and non-invasive ventilation (58%, n=101). Physiotherapists working in South Africa are somewhat involved in extubation (16%, n=28). The most common physiotherapy modalities used in ICU to facilitate respiratory muscle strengthening are exercises (81%, n= 138), early mobilisation out of bed and deep breathing exercises. (77%, n=134). Physiotherapists' involvement in the weaning of mechanically ventilated patients are not influenced by the type of ICU they work in (p>0.05), type of physiotherapy degree they have (p=0.24) or whether they are newly qualified physiotherapists or experienced physiotherapists (p=0.43).

Conclusion:
This survey shows that most physiotherapists who work in adult ICUs in South Africa are not involved in the weaning of mechanically ventilated patients. The survey does show that there is a need for physiotherapists to reconsider their role in ICU with regards to weaning patients from MV as current practice is not in keeping with the international practice of respiratory therapists in the United States of America (USA) and physiotherapists in the United Kingdom (UK), Australia and Europe.
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<tr>
<td>(%)</td>
<td>Percentage</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>BIPAP</td>
<td>Bi-Phasic Positive Airway Pressure</td>
</tr>
<tr>
<td>BP</td>
<td>Blood Pressure</td>
</tr>
<tr>
<td>CIM</td>
<td>Critical Illness Myopathy</td>
</tr>
<tr>
<td>CIP</td>
<td>Critical Illness Polyneuropathy</td>
</tr>
<tr>
<td>cmH₂O</td>
<td>Centimetres of Water</td>
</tr>
<tr>
<td>CNS</td>
<td>Central Nervous System</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>CPAP</td>
<td>Continuous Positive Airway Pressure</td>
</tr>
<tr>
<td>CPRG</td>
<td>Cardiopulmonary Rehabilitation Special Interest Group</td>
</tr>
<tr>
<td>CROP</td>
<td>Integrative Index of Compliance, Rate, Oxygenation, and Pressure</td>
</tr>
<tr>
<td>DBE</td>
<td>Deep Breathing Exercises</td>
</tr>
<tr>
<td>f</td>
<td>Breathing Frequency</td>
</tr>
<tr>
<td>FiO₂</td>
<td>Fractured of Inspired Oxygen</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>Hgb</td>
<td>Haemoglobin</td>
</tr>
<tr>
<td>HPCSA</td>
<td>Health Professionals Counsel of South Africa</td>
</tr>
<tr>
<td>HR</td>
<td>Heart Rate</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
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<td>IMTs</td>
<td>Inspiratory Muscle Trainers</td>
</tr>
<tr>
<td>LOS</td>
<td>Length of Stay</td>
</tr>
<tr>
<td>MHI</td>
<td>Manual Hyperinflation</td>
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<tr>
<td>MIP</td>
<td>Maximum Inspiratory Pressure</td>
</tr>
<tr>
<td>MV</td>
<td>Mechanical Ventilation</td>
</tr>
<tr>
<td>NIF</td>
<td>Negative Inspiratory Force</td>
</tr>
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<td>NIV</td>
<td>Non-Invasive Ventilation</td>
</tr>
<tr>
<td>P0.1</td>
<td>Airway Occlusion Pressure at 0.1 Seconds</td>
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<tr>
<td>PaCO₂</td>
<td>Partial Pressure of Carbon Dioxide</td>
</tr>
<tr>
<td>PAO₂</td>
<td>Partial Pressure of Alveolar Oxygen</td>
</tr>
<tr>
<td>PaO₂</td>
<td>Partial Pressure of Arterial Oxygen</td>
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<tr>
<td>PEEP</td>
<td>Positive End Expiratory Pressure</td>
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<tr>
<td>Pimax</td>
<td>Inspiratory Pressure Maximum</td>
</tr>
<tr>
<td>PS</td>
<td>Pressure Support</td>
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<td>PSV</td>
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<td>RR</td>
<td>Respiratory Rate</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>RSBI</td>
<td>Rapid Shallow Breathing Index</td>
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<tr>
<td>SpO₂</td>
<td>Oxygen Saturation at the Periphery</td>
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<td>SASP</td>
<td>South African Society of Physiotherapy</td>
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<tr>
<td>SBTs</td>
<td>Spontaneous Breathing Trials</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<td>SIMV</td>
<td>Synchronized Intermittent Mandatory Ventilation</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>V/Q</td>
<td>Ventilation/Perfusion</td>
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<td>VAP</td>
<td>Ventilator Associated Pneumonia</td>
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<td>VE</td>
<td>Minute Ventilation</td>
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<td>VT</td>
<td>Tidal Volume</td>
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<td>WOB</td>
<td>Work of Breathing</td>
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CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND

Mechanical ventilation (MV) is the defining event of ICU management. Although it is a lifesaving intervention in patients with acute respiratory failure and other diseases, a major goal of critical care clinicians should be to liberate patients from MV as early as possible to avoid the multitude of complications and risks associated with prolonged MV.

Some of these complications include deconditioning, muscle weakness, dyspnea, depression and anxiety, and reduced health-related quality of life (Gosselink et al 2008). Inactivity and immobility have significant and detrimental physiologic effects on the human body, including atelectasis, development of pressure sores and an increased susceptibility to aspiration and pneumonia. Moodie et al (2011) also associated prolonged MV with an increased risk of respiratory muscle weakness, critical illness myopathy or polyneuropathy, nosocomial infection and airway trauma. It is also associated with an increase in mortality, morbidity and ICU length of stay (LOS), as well as reduced functional status and quality of life. Prolonged MV further results in an increase in the financial burden of patients and health care systems (Hodgin et al 2009).

Patients who are ventilated require constant surveillance and decision making to optimise outcomes and reduce complications. Management of ventilation and its associated processes requires a multidisciplinary team, including nurses, physicians and allied health care workers such as physiotherapists (Hannan et al 2013; Bruton and McPherson 2004; Ely et al 2001). The process leading to discontinuation of mechanical support is known as weaning. This transition process may take many forms, ranging from abrupt withdrawal to gradual withdrawal from ventilatory support (Blackwood et al 2011). There are several options, or weaning modes, for decreasing support. They include intermittent T-piece trials involving short time periods of spontaneous breathing through a T-piece circuit; synchronized intermittent mandatory ventilation (SIMV), involving gradual reductions in the ventilator rate by increments of 1–3 breaths/ min; pressure support ventilation (PSV), involving the gradual reduction of pressure by increments of 2–6 cm of water (cmH\textsubscript{2}O); spontaneous breathing through the ventilator circuit with the application of continuous positive airway pressure (CPAP); combinations of these; and newer options such as bi-phasic positive airway pressure (BIPAP) (Blackwood et al 2011).
Non-invasive ventilation (NIV) provides an alternative method of supporting a patient’s respiration by using positive pressure ventilation with either an oronasal, nasal or total face mask. There is strong evidence that weaning using NIV is associated with reduced mortality, decreased ventilator associated pneumonia (VAP), reduced LOS in intensive care and in hospital, total duration of MV, and duration of invasive ventilation (Burns et al 2009). The involvement of physiotherapists in the application and management of patients on NIV has not yet been researched in South Africa.

Ely et al (2001) reports that it is important to conduct daily assessments of the patient's ability to breathe spontaneously. Spontaneous breathing trials (SBTs) are performed when the patient is haemodynamically stable with their condition improving with regard to the underlying cause of respiratory failure. The SBTs can be performed safely by non-physician health care providers using T-piece, CPAP without pressure support (PS), or with PS up to 7cmH\textsubscript{2}O, for duration of 30 minutes to two hours (Ely et al 2001).

Rapid weaning however has its own potential problems. Reducing mechanical support too quickly may result in fatigue or cardiovascular instability, either of which may ultimately delay the weaning process. Premature extubation, leading to reintubation, is associated with increased risk of pneumonia and with increased mortality (Brown et al 2011; Meade et al 2001 (a)).

In view of this, there has been increasing interest in delivering more consistent practice in ICUs by developing weaning protocols that provide structured guidelines. In South Africa, the use and development of weaning protocols by physiotherapists has not been determined. This may influence the future management of ventilated patients and thus further research in this area is required.

Patients who require prolonged MV may have reduced endurance of the respiratory muscles following successful weaning. Although it is not known whether prolonged MV is a cause of respiratory muscle weakness or an outcome, the presence of respiratory muscle weakness does increase the risk of respiratory pump failure (Chang et al 2005). Respiratory muscle weakness and, in particular, the imbalance between the muscle strength and load upon the respiratory system is one of the major determinants of weaning failure (Cader et al 2010). Martin et al (2002) investigated the effects of an inspiratory muscle strength training protocol on weaning of patients from MV and found that it did produce significant increases in threshold training pressure and thus aids in weaning of patients from MV. The use of inspiratory muscle trainers (IMTs) in South Africa to aid in the weaning of mechanically ventilated patients has not been researched. This is worth
determining as this may influence the success of weaning and extubation in critically ill patients.

Research done in Canada, United States of America (USA), Australia, Europe and the United Kingdom (UK) suggest that physiotherapists do have an important role to play in the weaning of mechanically ventilated patients (Hannan et al 2013; Ely et al 2001; Marelich et al 2000). There is currently no literature in South Africa that depicts the involvement of physiotherapists who work in ICU in the weaning of mechanically ventilated patients.

1.2 STATEMENT OF PROBLEM AND JUSTIFICATION FOR RESEARCH
Current research from the USA, Australia and the UK suggests that physiotherapists do have an important role to play in the management and weaning of mechanically ventilated patients. Some benefits of physiotherapists' involvement with such patients include decreased length of ICU stay and a decrease in the duration of MV as a result of rehabilitation provided in ICU. Thus far, no literature has been found depicting the involvement of South African physiotherapists working in critical care units, in the weaning of mechanically ventilated patients. In South Africa, the use and development of weaning protocols by physiotherapists has not been determined. The use of inspiratory muscle trainers (IMTs) in South Africa to aid in the weaning of mechanically ventilated patients has not been researched. Physiotherapists working in ICUs in South Africa closely survey their patients and their responses to treatment. Therefore physiotherapists do have significant information to contribute when the inter-professional team in ICU make decisions about weaning patients from MV. Therefore it is worthwhile determining to what extend these physiotherapists are currently involved in the weaning of mechanically ventilated patients in the units where they work.

1.3 RESEARCH QUESTION
What is the nature of involvement of physiotherapists in South Africa in the weaning process of mechanically ventilated patients in critical care units?

1.4 SIGNIFICANCE OF RESEARCH
The results of this study will highlight the most common modalities used as well as the modalities not so frequently used by physiotherapists in the weaning of mechanically ventilated patients. By determining the possible gaps in physiotherapy management of ventilated patients, cardiopulmonary lecturers and course coordinators can address these limitations through academic teaching and practical training of undergraduate physiotherapy students. This information may influence the future training of physiotherapists in the field of critical care and the management of mechanically ventilated patients.
patients in South Africa. This will contribute to progress and development in the field of physiotherapy training to prepare physiotherapy students for work in the ICU setting. For qualified physiotherapists, this study will provide information on the current trends of physiotherapy treatment modalities used in the ICU with specific reference to weaning of MV patients. In this way, physiotherapists would be able to determine the limitations, if any, to their current daily practice as well as opportunities for further professional development. In addition, this study will highlight if physiotherapists in South Africa are in keeping with international standards of practice with regards to weaning of mechanically ventilated patients.

1.5 RESEARCH AIM
To determine the nature of involvement of physiotherapists in South Africa in the weaning process of mechanically ventilated patients in ICU.

1.6 RESEARCH OBJECTIVES
- To determine if the number of patients in the ICU has an influence on the physiotherapists' involvement in the weaning of patients from MV.
- To determine if the type of ICU has an influence on the physiotherapists' involvement in the weaning of patients from MV.
- To determine if physiotherapists are involved in the development and implementation of weaning protocols for mechanically ventilated patients in their ICUs.
- To determine if physiotherapists are involved in titration of ventilator settings for patients during the weaning process.
- To determine what modalities physiotherapists in South Africa use to facilitate respiratory muscle strengthening to assist weaning of patients from MV.
- To determine if physiotherapists in South Africa are involved in the extubation of ventilated patients.
- To determine if there is a difference in involvement in weaning of mechanically ventilated patients between newly qualified and experienced physiotherapists.
- To determine if current physiotherapy involvement in the weaning of patients from MV in South Africa is in line with international physiotherapy practice according to the literature.
Chapter two consists of an in-depth discussion of the literature on the pathophysiology associated with ventilator requirement and dependence, weaning predictors, weaning assessment and criteria, methods of weaning, role of physiotherapy in critical care, weaning protocols and the role of allied health care workers in the administration of weaning protocols.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

Mechanical ventilation is instrumental in the rescue and maintenance of the patient with failing cardiorespiratory function. The capacity of mechanical ventilators to ventilate and oxygenate effectively has steadily improved. At first, the ventilator or respirator was envisioned essentially as a push–pull bellows pump with which to move conditioned gas into and out of the lungs. In the first decades of the 1900s, newly developed electric motor-driven pistons allowed enclosures for the patient’s thorax and abdomen and these came to be known as iron lungs (Marini 2013). In the 1960’s ventilatory equipment transitioned from negative pressure tanks that surrounded the patient to the familiar positive-pressure machines attached only through the airway and thus facilitated patient access. Pressure cycled devices that delivered intermittent positive pressure were utilised. Positive-pressure ventilators work by increasing the patient's airway pressure through an endotracheal or tracheostomy tube. Mechanical Ventilation is indicated when the patient's spontaneous ventilation is inadequate to maintain life, as prophylaxis for imminent collapse of other physiologic functions and when ineffective gas exchange occurs in the lungs (Marini 2013).

2.2 PATHOPHYSIOLOGY OF VENTILATOR REQUIREMENT

Patients require mechanical ventilatory support when the ventilatory and/or gas exchange capabilities of their respiratory system fail. This failure can be the result of processes both within the lung as well as in other organ systems, most notably the central nervous system (CNS) and the cardiovascular system (MacIntyre et al 2001).

2.2.1 Neurologic Issues

The ventilatory pump controller in the brainstem is a rhythm and pattern generator, which receives feedback from cortical, chemoreceptive and mechanoreceptive sensors. The failure of this controller can come from several factors. These factors can be either structural (e.g. brainstem strokes or central apneas) or metabolic (e.g. electrolyte...
disturbances or sedation/narcotic usage). The failure of the peripheral nerves also can be the result of either structural factors or metabolic/drug factors (MacIntyre et al 2001).

2.2.2 Respiratory System Muscle/Load Interactions

Ventilator dependence is the need for MV for more than six hours per day for more than 21 days (Klienhenz and Lewis 2000). Often, patients who exhibit ventilator dependence do so because there appears to be a mismatch between the performance capacity of the ventilatory pump and the load placed on it. There is ample evidence that ventilatory pump performance may be impaired in ventilator-dependent patients because ventilatory muscles are weak. This may be a consequence of atrophy and remodelling of the diaphragm and respiratory muscles from inactivity. It also may be a consequence of critical illness neuropathy and myopathy. A number of drugs (for example neuromuscular blockers, aminoglycosides, and corticosteroids) also can contribute to myopathy (Walsh et al 2004; MacIntyre et al 2001, Bruton et al 1999). Various metabolic derangements such as sepsis can also cause myopathy. “Sepsis elicits derangements at multiple subcellular sites involved in excitation contraction coupling, such as decreasing membrane excitability, injuring sarcolemmal membranes, altering calcium homeostasis due to effects on the sarcoplasmic reticulum, and disrupting contractile protein interactions” (Callahan and Supinski 2009). Muscle wasting occurs later and results from increased proteolytic degradation as well as decreased protein synthesis. The mechanisms leading to sepsis-induced changes are linked to excessive localized elaboration of pro-inflammatory cytokines, marked increases in free-radical generation, and activation of proteolytic pathways (Callahan and Supinski 2009).

Dynamic hyperinflation is an increase in lung volume that occurs when insufficient exhalation time prevents the respiratory system from returning to its resting end-expiratory equilibrium volume between breath cycles. This can put ventilatory muscles in a mechanically disadvantageous position.

Ventilation demands can increase as a consequence of increased oxygen demands in patients with sepsis or increased dead space in patients with obstructive pulmonary diseases. Lung compliance worsens as a consequence of lung oedema, infection, inflammation, fibrosis and chest wall abnormalities such as oedema or surgical dressings. Airway resistance worsens as a result of bronchoconstriction and airway inflammation. Additional load also can be imposed by narrow endotracheal tubes and by insensitive or poorly responsive ventilator demand valves (MacIntyre et al 2001). The consequences of such changes are respiratory muscle and diaphragm fatigue due to imbalances between the capacity of the ventilatory pump and the load placed on it. Clinically patients present
with respiratory distress with symptoms such as tachypnoea, tachycardia, laboured breathing, cyanosis, grunting and nasal flaring (MacIntyre 2005).

As these reasons for initially providing mechanical ventilatory support begin to resolve, the clinical focus must be directed toward strategies that enable removal of the patient from the ventilator as quickly as possible (MacIntyre 2005).

2.3 PATHOPHYSIOLOGY OF VENTILATOR DEPENDENCE

Factors that influence prolonged ventilator dependence include metabolic, gas exchange and cardiovascular factors.

2.3.1 Metabolic Factors and Ventilatory Muscle Function

Nutrition, electrolytes, hormones and oxygen transport are all metabolic factors that can affect ventilatory muscle function. Inadequate nutrition leads to protein catabolism and a loss of muscle performance (MacIntyre 2005; MacIntyre et al 2001). In contrast, overfeeding also can impair the ventilator withdrawal process by leading to excess carbon dioxide (CO₂) production, which can further increase the ventilation loads on ventilatory muscles (Walsh et al 2004). Studies have suggested that proper nutritional support can increase the likelihood of the success of ventilator withdrawal.

A number of electrolyte imbalances also can impair ventilatory muscle function. Phosphate deficiency has been associated with respiratory muscle weakness and ventilator withdrawal failure. Magnesium deficiency also has been reported to be associated with muscle weakness, although the relationship to ventilator dependence has not been specifically addressed. Finally, bicarbonate excretion from inappropriate over-ventilation (often occurring in patients with chronic obstructive pulmonary disease (COPD) with chronic baseline hypercapnia) can impair ventilator withdrawal efforts as the patient has a diminished capacity to compensate for hypercapnia. Severe hypothyroidism and myxedema directly impair diaphragmatic function and blunt ventilatory responses to hypercapnia and hypoxia (MacIntyre 2005; MacIntyre et al 2001).

Other hormonal factors that are important for optimal muscle function include insulin, glucagon and adrenal corticosteroids (Koksal et al 2004). As in other organs, adequate oxygen delivery and oxygen uptake by the ventilatory muscles is necessary for proper muscle function. Impaired oxygen delivery can be a consequence either of inadequate oxygen content or of inadequate cardiac output. Impaired oxygen uptake occurs most commonly during systemic inflammatory syndromes such as sepsis (MacIntyre 2005; MacIntyre et al 2001).
2.3.2 **Gas Exchange Factors**
Gas exchange abnormalities can develop during reductions in ventilatory support for several reasons. Various lung diseases produce ventilation/perfusion (V/Q) imbalances and shunts. Ventilator dependence thus may be a consequence of a need for high levels of expiratory pressure and/or the fraction of inspired oxygen (FiO₂) to maintain an adequate oxygen content (MacIntyre et al 2001).

2.3.3 **Cardiovascular Factors**
Several groups of investigators have drawn attention to cardiovascular responses in ventilator-dependent patients and have emphasized the association to ischemia and heart failure in susceptible patients with limited cardiac reserve. Accepted mechanisms of ventilator dependence resulting in cardiac abnormalities include the following:

a) increased metabolic demands, and hence circulatory demands, that are associated with the transition from MV to spontaneous breathing in patients with limited cardiac reserve;

b) increases in venous return as the contracting diaphragm displaces blood from the abdomen to the thorax;

c) increased left ventricular afterload that is imposed by negative pleural pressure swings (MacIntyre 2005; MacIntyre et al 2001).

For this reason, patients with limited cardiac reserve on MV are at risks of developing other cardiac abnormalities which in turn can cause ventilator dependence.

2.4 **DEFINITION OF WEANING**
The process leading to discontinuation of mechanical support is known as weaning. As a general definition, weaning from MV represents the period of transition from total ventilatory support to spontaneous breathing (Blackwood et al 2011). Ventilator management of the patient recovering from acute respiratory failure must balance competing objectives. On the one hand, aggressive efforts to promptly discontinue support and remove the artificial airway reduce the risk of ventilator-induced lung injury, nosocomial pneumonia, airway trauma from the endotracheal tube and unnecessary sedation. On the other hand, overly aggressive, premature discontinuation of ventilatory support or removal of the artificial airway can precipitate ventilatory muscle fatigue, gas-exchange failure and loss of airway protection (MacIntyre 2005).
2.5 WEANING PREDICTORS

The evaluation of patients’ readiness for liberation from MV starts with the resolution of respiratory failure and/or the disease entity that prompted the initiation of MV as well as the presence of a basic level of physiological readiness. There is a sound rationale that predicting readiness of patients to be successfully liberated from MV needs to be based on objective weaning predictors that can be applied in clinical decision making (El Khatib and Khalil 2008).

A large spectrum of weaning predictors has been studied, which can be divided into simple weaning indices, simple measures of load and capacity, integrative weaning indices and complex predictors requiring special equipment. The following variables have been researched to provide some predictive capacity with regards to weaning: minute ventilation (VE), negative inspiratory force (NIF), maximum inspiratory pressure (MIP), tidal volume (VT), breathing frequency (f), the ratio of breathing frequency to tidal volume (f/VT), P0.1/PImax (ratio of airway occlusion pressure 0.1 s after the onset of inspiratory effort to maximal inspiratory pressure), and CROP (integrative index of compliance, rate, oxygenation, and pressure) (El Khatib and Khalil 2008; Martinez et al 2003; Meade et al 2001 (b)).

2.5.1 Minute Ventilation (VE)

A VE less than 10 L/minute is associated with weaning success. Subsequent studies showed that VE values greater than 15-20 L/minute are helpful in identifying patients who are unlikely to be liberated from MV but lower values were not helpful in predicting successful liberation (El Khatib and Khalil 2008). This is also supported by Martinez et al (2003) who concluded that VE recovery time is an easy-to-measure parameter that may assist in determining respiratory reserve. Preliminary data demonstrates that it may be a useful adjunct in the decision to discontinue MV.

2.5.2 Maximal Inspiratory Pressure (Plmax)

Plmax (also called negative inspiratory force) is commonly used to test respiratory muscle strength and, in particular, the diaphragm. The proximal end of the endotracheal tube is occluded for 20 to 25 seconds with a one-way valve that allows the patient to exhale but not to inhale. Plmax equal to or less than -20 to -30 cmH₂O has a high sensitivity (ranging from 86% to 100%) and low specificity (ranging from 7% to 69%) for predicting liberation outcome from MV (El Khatib and Khalil 2008).
2.5.3 **Vital Capacity**

Another assessment of patient capacity is a simple vital capacity maneuver, in which the patient is asked to voluntarily take a maximal inspiration and subsequent inspiration. Vital capacity less than 1 L is associated with less ability to be removed from mechanical ventilatory support (MacIntyre 2005).

2.5.4 **Tidal Volume**

Spontaneous tidal volumes greater than 5 mL/kg have been considered as good predictors of weaning outcome (Walsh et al 2004). El-Khatib and Khalil (2008) showed that approximate entropy of the tidal volume and breathing frequency patterns, a technique that measures the amount of regularity in a series, is a useful indicator of reversibility of respiratory failure.

2.5.5 **Breathing Frequency**

Tachypnea (respiratory rate (RR) equal to or greater than 30-35 breaths/minute) is a sensitive marker of respiratory distress but can prolong intubation when used as an exclusive criterion (El Khatib and Khalil 2008). Meade et al (b) (2001) reported that the degree of regularity or irregularity in the pattern of the breathing frequency as reflected by approximate entropy rather than the absolute value of the breathing frequency is more important in discriminating between weaning success and failure. They have shown that a highly irregular spontaneous breathing frequency pattern with or without periods of apnea is not a good indicator for liberation from MV outcome (El Khatib and Khalil 2008; Meade et al 2001(b)).

2.5.6 **The Ratio of Breathing Frequency to Tidal Volume**

Yang and Tobin (1991) were the first to perform a prospective study of 100 medical patients receiving MV in the ICU. They demonstrated that the ratio of frequency to tidal volume (rapid shallow breathing index (RSBI)) obtained during the first minute of a T-piece trial and at a threshold value of equal to or less than 105 breaths/minute/L was a significantly better predictor of weaning outcomes than other ‘classic’ and commonly used parameters. Since then, RSBI has been studied in large numbers of patients and appears to have predictive utility that is superior to other commonly used parameters (Chao and Scheinhorn 2007). However, there remains a principle shortcoming in the RSBI: it can produce excessive false positive predictions; that is, patients fail weaning outcome even when RSBI is equal to or less than 105 breaths/minute/L. Also, the RSBI has less predictive power in the care of patients who need ventilatory support for more than eight days and may be less useful in patients with COPD and the elderly. Nevertheless, a RSBI of equal to or less than 105 breaths/minute/L should prompt a SBT of 30 to 120 minutes to further assess patient
readiness for liberation from MV (El Khatib and Khalil 2008; Meade et al 2001(b); Bruton et al 1999).

2.5.7 Rapid Shallow Breathing Index (RSBI) Rate
Stawicki (2007) reports that there is evidence that the RSBI rate, or a measure of change of RSBI over time, may offer more predictive value than RSBI alone. The RSBI rate is calculated by obtaining the difference between the initial RSBI and the final RSBI, and then dividing the result by the initial RSBI. The resulting number is then multiplied by 100. It was shown that RSBI rate of less than 20% was over 90% sensitive and 100% specific for predicting weaning success (Stawicki 2007).

2.5.8 P0.1/Plmax
The airway occlusion pressure (P0.1) is the pressure measured at the airway opening 0.1 seconds after inspiring against an occluded airway. In mechanically-ventilated patients, P0.1 can be measured by inserting a shutter in the ventilator's inspiratory line, as near as possible to the patient, and recording airway pressure tracing at the Y piece. However, in patients' ventilated using assist-control or pressure-support ventilation it is possible to use the demand valve system's prolonged time of response to obtain P0.1. It can also be measured as an integrated function in standard respirators (e.g. Evita, Dräger, Lübeck, Germany). The airway occlusion pressure is measured by the ventilator's pressure transducer in the expiratory limb just before the exhalation valve (El Khatib and Khalil 2008; MacIntyre 2005).

The P0.1 is effort independent and correlates well with central respiratory drive. When combined with Plmax, the P0.1/Plmax ratio at a value of less than 0.3 has been found to be a good early predictor of weaning success and may be more useful than either P0.1 or Plmax alone. Previously, the clinical use of P0.1/Plmax has been limited by the requirement of special instrumentation at the bedside; however, new and modern ventilators are incorporating respiratory mechanics modules that provide numerical and graphical displays of P0.1 and Plmax (El Khatib and Khalil 2008; MacIntyre 2005).

2.5.9 Integrative Index of Compliance, Rate, Oxygenation, and Pressure (CROP)
The CROP index is an integrative index that incorporates several measures of readiness for liberation from MV, such as dynamic respiratory system compliance, spontaneous breathing frequency (f), arterial to alveolar oxygenation (partial pressure of arterial oxygen (PaO\textsubscript{2})/partial pressure of alveolar oxygen (PAO\textsubscript{2})), and Plmax.

The CROP index assesses the relationship between the demands placed on the respiratory system and the ability of the respiratory muscles to handle them (El Khatib and Khalil
2008). Yang and Tobin (1991) reported that a CROP value greater than 13 mL/breaths/minute offers a reasonably accurate predictor of weaning MV outcome. In another study investigating patients with COPD, Alvisi et al (2000) showed that a CROP index at a threshold value of greater than 16 mL/breaths/minute is a good predictor of weaning outcome. However, one disadvantage of the CROP index is that it is somewhat cumbersome to use in the clinical setting as it requires measurements of many variables with the potential risk of errors in the measurement techniques or the measuring device, which can significantly affect the value of the CROP index (El Khatib and Khalil 2008; MacIntyre 2005).

2.6 WEANING ASSESSMENT AND CRITERIA

Successful weaning requires both sound clinical judgement and a solid evidence base for decisions made. Information required for successful weaning falls into three subcategories: empirical objective, empirical subjective and abstract information (Blackwood et al 2004).

In relation to weaning, empirical objective information is that acquired by observation and measurement of the physiological parameters in relevant physiological systems. Such information is subsequently independently verifiable. There was widespread agreement on the following objectively verifiable information being pertinent to successful weaning:

a) Resolution of the state which necessitated MV for example recovery from a depressed conscious level (Glasgow Coma Scale (GCS)), from a distributive shock state (need for vasoactive agents), or from lower respiratory tract infection (severity of radiographic infiltrates) (MacIntyre 2005; Blackwood et al 2004).

b) Most or all of the patient’s physiological observations are within an acceptable range such as RR, VT, heart rate (HR), blood pressure (BP) and electrolytes. Weaning decisions are seen as requiring information relating to many systems, not just the respiratory system, because of the interactions between and interdependence of organ systems (MacIntyre 2005; Blackwood et al 2004).

Empirical subjective information refers to information acquired by clinically examining the patient. It involves observing and identifying relevant signs which may not be independently verifiable at a later stage, for example, if chest movements were coordinated and effective, or if diaphoresis or clamminess were present. Such information is empirical in that its acquisition involves observation and touch, but does not lend itself easily to objective verification at a later stage (Blackwood et al 2004).
Abstract information is deemed important in decision-making and does not fit easily into either of the above categories. An example of this is when health care providers describe information whose acquisition arose from experience such as describing how patients look during weaning. Phrases commonly used are ‘not right’ and ‘not comfortable’. This information is abstract because no descriptors are used to define such terms but fall under an intuitive component to decision-making (Blackwood et al 2004).

According to MacIntyre et al (2001), if the following criteria are satisfied, the patient should undergo a formal assessment to determine if the patient is able to be weaned from the ventilator:

a) Evidence for some reversal of the underlying cause for respiratory failure;

b) Adequate oxygenation (e.g. \( \frac{\text{PaO}_2}{\text{FiO}_2} \) ratio > 150 to 200; positive end expiratory pressure (PEEP) ≤5 to 8 cmH\(_2\)O; \( \text{FiO}_2 \) ≤0.4 to 0.5); and pH ≥7.25;

c) Hemodynamic stability, as defined by the absence of active myocardial ischemia and the absence of clinically significant hypotension (i.e. a condition requiring no vasopressor therapy or therapy with only low-dose vasopressors such as dopamine or dobutamine, ≤ 5 \( \mu \)g/kg/min); and

d) The capability to initiate an inspiratory effort.

Objective measurements
a) Adequate oxygenation (e.g. \( \text{PaO}_2 \geq 60 \) mm Hg on \( \text{FiO}_2 \leq 0.4 \); PEEP ≥ 5–10 cm H\(_2\)O; \( \frac{\text{PaO}_2}{\text{FiO}_2} \) ≥ 150–300);

b) Stable cardiovascular system (e.g. HR ≤ 140; stable BP; no or minimal pressors)

c) Afebrile (temperature < 38°C)

d) No significant respiratory acidosis

e) Adequate haemoglobin (e.g. Hgb ≥ 8–10 g/dL)

f) Adequate mentation (e.g. arousable, GCS ≥ 13, no continuous sedative infusions)

g) Stable metabolic status (e.g. acceptable electrolytes)

Subjective clinical assessments
a) Resolution of disease acute phase

b) Physician believes discontinuation possible

c) Adequate cough
In addition, Chen et al (2009) reported that successful weaning of a patient from the ventilator depends on the following factors:

a) patient motivation;

b) presence of an experienced multidisciplinary team of nurses, physicians, respiratory therapists and nutritionists;

c) concern on the part of family members about the patient's condition and nursing care; and

d) communication among the patient and family members regarding the weaning plan and its implementation.

It is important that all the factors mentioned above be considered part of weaning criteria and assessment to holistically and successfully manage mechanically ventilated patients.

2.7 METHODS OF WEANING

2.7.1 Spontaneous Breathing Trial

Once weaning criteria has been met subsequent discontinuation of ventilator support should be attempted (MacIntyre 2005). A quick and direct method of testing readiness for liberation from MV is simply to initiate a trial of unassisted spontaneous breathing in the form of either a T-piece (artificial airway connected to T-piece connector with oxygen flow provided through wide-bore tubing) trial, a continuous positive airway pressure (CPAP) trial, or a pressure support ventilation (PSV) trial. The classical approach for readiness testing is the SBT with either a T-piece or a CPAP trial (El-Khatib and Khalil 2008). T-piece or CPAP trials can be used for two objectives: to test readiness for liberation from MV or to implement a weaning protocol that involves increasing periods of unsupported spontaneous breathing interspersed with periods of full ventilatory support (Blackwood et al 2011).

There is convincing evidence that a SBT with either T-piece, CPAP, or PSV should be conducted for 30 to 120 minutes in order to test patient readiness for liberation from MV (MacIntyre 2005).

One advantage of using PSV instead of T-piece or CPAP trials is its capacity to overcome the work of breathing imposed by the ventilator and the endotracheal tube. This is usually as a result of a significant stay on MV during which it is anticipated that the tube radius is narrowed or there are secretions lining the endotracheal tube lumen. One major concern remains the level of PS required to overcome the imposed work of breathing (WOB) while
avoiding either over-assisting, which can result in excessive numbers of extubation failures, or under-assisting, which can result in unnecessarily prolonged MV. Studies have shown that the appropriate PSV level differs substantially from patient to patient. Most studies have recommended the use of 5 to 7 cmH$_2$O of PS to offset the imposed WOB by the breathing circuit, ventilator and endotracheal tube resistances (El-Khatib and Khalil 2008).

Once the patient is on a trail of unassisted spontaneous breathing, continuous assessment needs to occur to determine SBT success or failure (Blackwood et al 2011).

2.7.2 T-Piece Weaning
This involves the patient simply breathing spontaneously via the endotracheal tube, through a T-piece and tubing attached to the gas source. The application of T-piece weaning may extend over the course of a few days and thus is different from the once off SBT application of 30 to 120 minutes per day. T-piece weaning is a very simple and therefore low cost method of weaning, but involves abrupt transition from ventilator support to spontaneous breathing, with consequent rapid change from positive to negative intrathoracic pressures. CPAP can be added to counterbalance some of the problems this may cause. The theory behind the use of T-piece weaning is that of alternating periods of respiratory effort with periods of rest or reduced activity. The main disadvantage of T-piece weaning is the lack of connection to MV, and thus the higher level of supervision required. This lack of connection is also an advantage, however, since there is no additional WOB imposed from ventilator valves and circuits (Blackwood et al 2011).

2.7.3 Synchronised Intermittent Mandatory Ventilation (SIMV)
This is a mode in which the ventilator breaths are triggered by the patient, but if the patient fails to take a breath within a designated time frame the ventilator will provide a breath. This method of weaning involves gradually reducing the number of ventilator-delivered breaths, thereby allowing the patient to increase the number of spontaneous breaths between mandatory breaths (Blackwood et al 2011).

2.7.4 Pressure Support Ventilation (PSV)
This is a form of pressure controlled ventilation. In this mode the patient must trigger each breath and the machine generates and maintains a pre-selected pressure. The PSV can be used with or without SIMV to allow the patient to retain relatively wide control over RR and timing, inspiratory flow rate and VT. It can, however, be difficult to judge the appropriate level of PSV to set, as too high results in insufficient patient work, but too low can result in patient fatigue. The theory behind the use of PSV is to improve the efficacy of the patient’s own spontaneous breaths by reducing external respiratory work and the oxygen
consumption of respiratory muscles. It is also useful to overcome the extra WOB imposed by the endotracheal tube and the ventilator circuits (Blackwood et al 2011).

2.7.5 Non-Invasive Ventilation and its Effects on Weaning

In their efforts to optimise the timing of liberation from invasive ventilation, clinicians are challenged by a trade-off between the risks associated with failed extubation and the complications associated with prolonged invasive ventilation. Non-invasive weaning offers a potential solution to this trade-off (Burns et al 2009). Non-invasive ventilation provides an alternative method of supporting a patient’s respiration by using positive pressure ventilation with either an oronasal, nasal or total face mask at the patient-ventilator interface, thus avoiding some of the complications of artificial airways such as nosocomial pneumonia and feeding aspiration (Trevisan and Vieira 2008). Various modes of ventilation can be applied, similar to those used with invasive ventilation while preserving the patient’s ability to speak and cough. Similar to invasive ventilation, NIV can reduce the frequency of breathing, augment VT, improve gas exchange and rest the muscles of respiration (Burns et al 2009).

There has been increasing interest in the use of NIV when used as a technique to facilitate the discontinuation of invasive ventilatory support. In a study conducted by Trevisan and Vieira (2008), the results suggest that the combination of early extubation and NIV is a good alternative for ventilation in a group of heterogeneous patients who initially failed weaning. Non-invasive ventilation use resulted in efficient gas exchange, a tendency to decrease ICU and hospital stays and a reduction in the incidence of pneumonia as well as in the need for tracheostomy when compared with conventional invasive MV weaning. Therefore, NIV is a useful and safe strategy that may be considered during MV weaning, particularly when used in selected patients, such as those with COPD and hypercapnic respiratory failure or respiratory acidosis (Trevisan and Vieira 2008). Patients with COPD might be ideally suited to NIV given its ability to offset respiratory muscle fatigue and tachypnoea, augment VT and reduce intrinsic PEEP (Burns et al 2009).

Other studies that reported the benefit in NIV is that by Ferrera et al (2003) and Nava et al (1998). They showed that earlier extubation with NIV resulted in shorter duration of MV and LOS, less need for tracheostomy, lower incidence of complications and improved survival. Thus it can be said that NIV is a useful and safe strategy that may be considered during weaning of patients from MV.
2.8 **ROLE OF PHYSIOTHERAPY IN CRITICAL CARE**

Intensive care is a dynamic environment where physiotherapists are vital members of the multidisciplinary team providing a spectrum of care from acute respiratory management to rehabilitation interventions. Physiotherapists are involved in the management of patients with acute, subacute and chronic respiratory conditions and in the prevention and treatment of the sequelae of immobility and recumbency. Their role varies across units, hospitals and countries, with respect to patient referral, treatment goals and selection of treatment interventions. The aims of physiotherapy for patients who present with respiratory dysfunction are to improve global and/or regional ventilation and lung compliance, to reduce airway resistance and the WOB, to clear airway secretions and enhance inspiratory muscle function promoting recovery of spontaneous breathing (Gosselink et al 2011; Gosselink et al 2008). Various interventions are used by physiotherapists in the management of their patients to achieve these aims. The interventions chosen should depend on each individual patient’s needs as identified through thorough assessment.

2.8.1 **Positioning**

Positioning describes the use of body positions as a specific treatment technique. Positioning is used with the aim to improve ventilation/perfusion (V/Q) matching, lung volumes and mucociliary clearance, to reduce the WOB and the work of the heart (Clini and Ambrosino 2005). Specific examples of positioning to be used in the ICU setting include upright positioning to improve lung volumes and decrease the WOB in patients who are being weaned from MV. Side lying with the affected lung uppermost is used to improve V/Q matching for patients with unilateral lung disease (Gosselink et al 2011; Clini and Ambrosino 2005).

2.8.2 **Limb Exercises**

These exercises involve moving the patient’s limb in an active assisted or active manner. During a period of inactivity muscle mass declines and the potential efficiency of a muscle to perform aerobic exercise declines. Loss of strength was found to be greatest during the first week of immobilisation, declining by as much as 40% after the first week (Morris et al 2008).

Skeletal muscles are composed of two major types of fiber. Type I fibers are mainly involved in aerobic activity, while type II fibers have a lower capacity for this activity. Deconditioning causes a distinct transformation of subtypes of type II fibers, for example type IIa fibers are converted to type IIb fibers, the former having a higher aerobic capacity (Clini and Ambrosino 2005). To prevent this deconditioning, patients are assisted through actively moving or turning in bed, getting out of bed via mechanical lifting machines,
standing, transfers from bed to chair and walking. The benefit of mobilisation is that it may optimise oxygen transport by enhancing alveolar ventilation and V/Q matching. Exercise further provides a gravitational stimulus to maintain or restore normal fluid distribution in the body and to reduce the effects of immobility (Clini and Ambrosino 2005). Limb exercises (passive, active assisted, or active resisted) may be performed with critically ill patients with the aim of maintaining joint range of motion, but also of improving soft-tissue length, muscle strength and function and decreasing the risk of thromboembolism (Gosselink et al 2011; Gosselink et al 2008). Resistance training can augment muscle mass, force generation and oxidative enzymes. This in turn can improve \( O_2 \) extraction and efficiency of muscle \( O_2 \) kinetics thus preventing muscle atrophy (Gosselink et al 2008).

2.8.3 Early Mobilisation
The risk of moving a critically ill patient is weighed against the risk of immobility and recumbency and when employed requires stringent monitoring to ensure the mobilisation is instituted appropriately and safely. Acutely ill, uncooperative patients will be treated with modalities such as passive range of motion, muscle stretching, splinting, body positioning, passive cycling with a bed cycle, or electrical muscle stimulation that will not need cooperation of the patient and will put minimal stress on the cardiorespiratory system (Gosselink et al 2011; Gosselink et al 2008). On the other hand, the stable cooperative patient, beyond the acute phase of illness but still on MV, will be able to be mobilised on the edge of the bed, transferred to a chair, perform resistance muscle training or active cycling with a bed cycle or chair cycle and walk with or without assistance (Gosselink et al 2011).

2.8.4 Chest Physiotherapy
Chest physiotherapy is one of the most frequently performed interventions in the ICU. There are many reasons why a patient on MV may benefit from chest physiotherapy treatment. These include mucociliary dysfunction, altered lung volumes when patients are ventilated, increased pulmonary shunt, the effects of neuromuscular weakness on expiratory flows and an increased risk of nosocomial pneumonia. So far, chest physiotherapy has been recognised as an important aspect to achieve successful weaning from the ventilator (Branson 2007). Lack or reduction of the cough reflex in an intubated patient may be associated with retention of bronchial secretions and the risk of pulmonary infection. Several physiotherapy techniques are used to facilitate adequate bronchial drainage in these patients, mainly depending on the patient's compliance and staff expertise (Clini and Ambrosino 2005).

Chest physiotherapy includes the use of percussions and vibrations. Percussions may be performed manually (using cupped hands) by clapping the chest wall over the affected area
of the lung. Vibrations may be applied manually or via mechanical devices by vibrating, shaking, or compressing the chest wall during the expiratory phase. These techniques are believed to increase clearance of airway secretions by the transmission of an energy wave through the chest wall (Branson 2007).

Interventions aimed at increasing inspiratory volume (deep breathing exercises (DBE), manual hyperinflation (MHI), mobilisation and body positioning) may affect lung expansion, increase regional ventilation, reduce airway resistance and optimise pulmonary compliance (Gosselink et al 2011; Gosselink et al 2008). Interventions aimed at increasing expiratory flow include forced expirations such as huffing, coughing and MHI (Clini and Ambrosino 2005). These techniques may be performed on fully conscious patients who are able to follow command. Manually assisted cough, using thoracic or abdominal compression may be indicated for patients with expiratory muscle weakness, fatigue or denervation due to spinal cord injury. For mechanically ventilated patients MHI or ventilator hyperinflation, positive end-expiratory pressure ventilation, postural drainage, chest wall compression and airway suctioning may assist in clearance of secretions (Gosselink et al 2011).

Manual hyperinflation is a technique that involves disconnecting the patient from the ventilator and inflating the lungs with a large tidal volume via a manual resuscitator bag. Manual hyperinflation is used with the aim of preventing pulmonary collapse, re-expanding collapsed alveoli, improving oxygenation and lung compliance and increasing movement of pulmonary secretions toward the central airways (Clini and Ambrosino 2005; Maa et al 2005).

2.8.5 Respiratory Muscle Training

As with other skeletal muscles, the ventilator pump may also be profoundly altered by the effects of bed-rest and of the disease itself and any comorbid conditions. Weakness or fatigue of the diaphragm and accessory muscles of inspiration is widely recognised as a cause of failure to wean from MV. A reduction in the capacity of the respiratory muscle pump may also occur due to phrenic nerve injury, critical illness myopathy (CIM) and critical illness polyneuropathy (CIP), corticosteroids, endocrine or nutritional factors (Epstein 2009). There is increasing evidence to show MV itself may adversely affect the diaphragm’s structure and function, which has been termed ventilator-induced diaphragmatic dysfunction (Petrof et al 2005). The combination of positive pressure ventilation and PEEP may unload the diaphragm therefore subjecting it to changes in myofibre length, which may account for its rapid atrophy (Moodie et al 2011). In addition, patients who undergo prolonged periods of MV demonstrate a decrease in respiratory muscle endurance and are at risk of respiratory muscle fatigue (Moodie et al 2011).
Interventions such as DBE, MHI and IMT have a role in the treatment of respiratory muscle weakness (Moodie et al 2011). Inspiratory muscle training is a technique that targets the muscles of inspiration namely the diaphragm and accessory inspiratory muscles. The aim is to increase inspiratory muscle strength and endurance (Cader et al 2010).

Sprague and Hopkins (2003) hypothesised that IMTs may work to assist patients in weaning from MV by any of the following mechanisms:

a) improving the function of the respiratory muscle pump via changes in muscle fibre type, size and physiological efficiency,

b) improving the activation of the respiratory muscle pump via the adaptation of neural pathways to allow more efficient motor unit recruitment, and

c) improving the breathing pattern, strength and endurance of the inspiratory muscles may reduce ventilator dependence over time and facilitate spontaneous breathing. Reducing ventilation time may help to reduce the incidence of ventilator-associated complications and may decrease ICU and hospital LOS (Sprague and Hopkins 2003).

Martin et al (2002) reported that inspiratory muscle strength training has been shown to improve respiratory strength and exercise performance in individuals with inspiratory muscle weakness and poor exercise tolerance. Inspiratory muscle trainers can be performed with resistance or pressure threshold devices. Resistance training devices typically consists of breathing through a series of adjustable orifices providing flow dependent resistance that decrease as airflow decreases (Martin et al 2002). Pressure threshold devices provide a constant, sustained pressure challenge throughout the entire inspiration that is independent of airflow. When inspiring through a pressure threshold device, the individual must generate a minimum inspiratory muscle force to overcome a threshold load. This is achieved by generating an inspiratory pressure sufficient to open the spring-loaded valve and this pressure must be maintained throughout the inspiration (an isotonic load).

In ventilated patients, IMTs can be undertaken in several ways: isocapnic/ normocapnic hyperpnoea training, resistive flow training, threshold pressure training or adjustment of the ventilator settings to provide a training load for the inspiratory muscles (Moodie et al 2011).

Inspiratory muscles respond to training in the same way as other skeletal muscles in regard to the principles of overload, specificity and reversibility. In healthy people and in people
with COPD, inspiratory muscle training increases respiratory muscle strength and endurance (Moodie et al 2011). In patients who have failed to wean from MV using standard weaning techniques, several case reports have demonstrated increases in inspiratory muscle strength measured by MIP after the use of IMTs, followed by successful weaning (Moodie et al 2011; Sprague and Hopkins 2003).

2.8.6 Extubation

Extubation is the removal of the endotracheal tube and should be considered and attempted after patients have passed a SBT as part of the liberation process from MV (Vivar and Esterban 2003). In South Africa, extubation is within the scope of physiotherapy practice and is often performed with the assistance of the ICU nursing staff. Most important for successful extubation is the patient’s ability to protect the airway by coughing and clearing it of secretions. In a study by Khamiees et al (2001) the probability of successful extubation was highly positively correlated with cough strength and inversely correlated with the amount of secretions in the airway. Patients with moderate to strong coughs were four times more likely to be extubated successfully than those with weak coughs, and those with no or mild secretions were more than eight times as likely to be extubated successfully than those with moderate to abundant secretions. Poor cough strength and greater secretions were synergistic in predicting extubation failure (Su et al 2010; Vivar et al 2006; Vivar and Esterban 2003).

Extubation failure is defined as the need for reintubation within 48 to 72 hours after extubation (El-Khatin and Khalil 2008). McLean et al (2006) reports that rates of reintubation range from 4% - 33% and potentially induces harm with associated airway trauma, gastric aspiration, acute lung injury, cardiovascular compromise and hypoxia. Compared with the first intubation, with reintubation, the estimated risk for nosocomial pneumonia is eight times higher and the increase for mortality increases six to twelve fold (McLean et al 2006). Causes of extubation failure include airway obstruction, respiratory failure (defined as fatigue or respiratory distress), inability to protect the airway, reduced level of consciousness, aspiration, excessive secretions, haemodynamic failure and neurological deterioration (Salam et al 2004; Vivar and Esterban 2003). Some of these factors can be assessed by physiotherapists and may influence extubation success.

2.9 WEANING PROTOCOL DESIGN AND IMPLEMENTATION

Protocols are meant as guides and should not be used to replace clinical judgment, but rather to complement it. Information obtained from the literature does not support endorsement of any one ventilator discontinuation protocol (Blackwood et al 2011; Ely et al 2001).
Goodman (2006) described how a weaning protocol was designed and introduced into the critical care unit of a district general hospital. He indicated that a multi-professional group interested in weaning needs to work together to formulate a protocol, to implement the protocol into the ICU and to maintain an on-going auditing system. While each institution must customise the weaning protocols to its local needs, there are important general concepts that may ease the process of implementation and enhance success. Goodman stated that protocols should not be viewed as static constructs, but rather dynamic tools in evolution, which can be modified to accommodate new data and/or clinical practice guidelines. In addition, institutions must be prepared to commit the necessary resources (for example, technology and personnel) to develop and implement weaning protocols (Goodman 2006).

### 2.9.1 Role of Health Care Providers in the Administration of Weaning Protocols

There is clear evidence that non-physician health care providers (e.g. respiratory therapists and nurses) can execute protocols that enhance clinical outcomes and reduce costs for critically ill patients. In recent years, three randomised controlled trials incorporating 1,042 patients also have demonstrated that outcomes for mechanically ventilated patients who were managed using health care provider-driven protocols were improved over those of control patients managed with standard care (MacIntyre 2005). Specifically, Ely et al (2001) published the results of a two-step protocol driven by health care providers using a daily screening procedure followed by a SBT in those who met the screening criteria. The discontinuation of MV then was recommended for patients tolerating the SBT. Patients managed with the protocol had a higher severity of illness than the control subjects, were removed from the ventilator 1.5 days earlier (with two days less weaning) and had 50% fewer complications related to the ventilator (Ely et al 2001).

According to Dries et al (2004), a nursing-implemented sedation protocol for patients receiving MV was associated with a 50% reduction in the duration of MV, and two day and three day reductions in the median ICU and hospital LOS respectively.

Interventions specific to weaning performed by Canadian and American respiratory therapists include the screening and implementation of SBTs and titration of ventilator settings of FiO₂, PEEP, ventilation rate, and pressure support (PS) (Ely et al 2001; Marelich et al 2000; Kollef et al 1997). In addition, research supports the use of non-invasive ventilation (NIV) and inspiratory muscle trainers (IMTs) in American hospitals to facilitate weaning from MV (Martin et al 2002; Burns et al 2009).
In the UK, nurses are more proactive and have a higher level of responsibility and autonomy in the management of ventilation and weaning compared to respiratory therapists in America and Canada (Blackwood et al 2009). However in a study conducted by Bruton and McPherson (2004), it was found that physiotherapists in the UK are involved in the development of weaning protocols, daily screening and implementation of SBTs and extubation. In addition, NIV is an intervention practiced by the MDT including physiotherapists (Bruton and McPherson 2004).

In Australia the multidisciplinary team employs active measures to optimize medical status, enhance sputum clearance and improve sleep–wake cycle. Physical therapy is implemented to maintain or improve peripheral muscle strength. Ventilation is undertaken predominantly in assist-control modes to improve sleep quality, with weaning generally consisting of progressive SBTs. NIV is used selectively both as a bridge to spontaneous breathing and to support those who require ongoing nocturnal ventilatory support (Hannan et al 2013). Inspiratory muscle trainers have proven to be beneficial in patients needing prolonged MV whom are at risk of respiratory muscle fatigue. The recommendation and application of IMTs in Australia are the responsibility of physiotherapists (Chang et al 2005).

In Europe, Carpene et al (2010) reported that respiratory physiotherapists are involved in the development and implementation of weaning protocols. Weaning interventions practiced include the progressive reduction in PS levels and daily screening and implementation of SBTs. Gosselink et al (2011) reports the additional physiotherapy interventions and techniques practiced in European ICUs include the application of chest physiotherapy, DBE, IMTs, body positioning, MHI, NIV, early physical activity (passive, active and resisted) and early mobilisation.

Only one study could be found that investigated the benefits of a weaning and extubation protocol led by nursing staff and physiotherapists in a South African trauma ICU setting on MV days and ICU length of stay. The weaning intervention reported was daily screening of weaning readiness and implementation of SBTs and extubation. The results of this study showed a clinically significant reduction in MV time, which reduced the risks of ventilator associated complications for the trauma patients. The study also reported a low reintubation rate which can be attributed to the fact that the criteria used in the weaning protocol ensured that all patients were ready for extubation. This study portrays the benefit in implementing a weaning and extubation protocol led by nursing staff and physiotherapists (Plani et al 2012).
CONCLUSION OF LITERATURE REVIEW

The ventilator-discontinuation process of weaning requires proper assessment and management. Assessment of respiratory physiologic signals can give insight into the loads placed on patients’ respiratory muscles and patients’ abilities to be weaned from MV. There are several weaning options including intermittent T-piece trials involving short periods of SBTs, gradual reduction in PS and ventilation rate and NIV. Physiotherapists are vital members of the multidisciplinary team who provide significant information on the decision-making to wean patients from MV. Research supports the use of the following physiotherapy techniques to aid in weaning of mechanically ventilated patients: chest physiotherapy, positioning, exercise therapy, early mobilisation, MHI and respiratory muscle strengthening with the use of IMTs. Research further supports the use of multidisciplinary team developed and implemented weaning protocols. Some of the benefits reported include reduced duration of MV, ICU LOS, occurrence of VAP and reduced costs. As physiotherapists are part of the multidisciplinary team, it is important to determine to what extent physiotherapists in South Africa are involved in the weaning of mechanically ventilated patients.

The next chapter of this research report will describe the methodology that was followed to conduct a survey amongst physiotherapists who work in ICU in South Africa in order to answer the research question.
CHAPTER 3

3. METHODOLOGY

The study design, sample population, data collection procedure and instruments used are discussed in detail. The main methods used for data analysis are given. Ethical considerations are addressed towards the end of this chapter.

3.1 STUDY DESIGN

A cross sectional survey based design was used. A self-administered questionnaire was used to obtain data for the study.

3.2 SUBJECTS

3.2.1 Sample Selection and Demographics

Participants of this study included all cardiopulmonary physiotherapists who work in adult ICUs of hospitals in the public and private sectors throughout South Africa. The Department of Health was contacted to determine the name and location of all the public hospitals in South Africa that have ICU facilities. In total 51 public hospitals were included. The head of each public hospital physiotherapy department was then contacted telephonically and via email with information about the study. This included a brief description of the study, purpose of the study as well as inclusion and exclusion criteria. The head of the physiotherapy department was further asked whether email or postal surveys were preferred as the method of questionnaire delivery.

The Hospital Association of South Africa was used to source the main private hospitals in South Africa, namely the private hospitals under the Netcare, Mediclinic and Life hospital brands. Each private hospital was contacted telephonically and then via email to acquire the names and contact details of the private physiotherapy practices that serve the hospital. Each practice owner was contacted telephonically and thereafter via email and the same procedure, as outlined above, was followed to obtain permission to distribute questionnaires to physiotherapists who work for their practice in the ICU. A total of 107 emails with a link to the online survey were sent.

The national chairperson of the South African Society of Physiotherapy’s (SASP) Cardiopulmonary Physiotherapy Rehabilitation Special Interest Group (CPRG) was contacted to email the link to the online survey to all of its 151 members.
3.2.2 Inclusion Criteria
Physiotherapists who belong to the CPRG of the SASP and physiotherapists who work in ICUs of hospitals in the public and private sectors in South Africa.

3.2.3 Exclusion Criteria
Physiotherapists who do not work in ICU were not included. In addition, physiotherapy assistants, physiotherapy students and community service physiotherapists were not included.

3.2.4 Sample Size
The target population was the number of physiotherapists who worked in adult ICU in the public or private sectors in South Africa. At the time of the pilot study, the CPRG of the SASP had 151 members. Not all qualified physiotherapists are members of the CPRG and therefore the sample size for this survey was expected to be greater than 151. For this study, 200 physiotherapists in the public sector and 225 physiotherapists in the private sector were invited to participate in the survey.

3.3 STUDY PROCEDURES
3.3.1 Instrumentation
The questionnaire was developed by the researcher according to the available literature on the involvement of physiotherapists in the weaning of MV patients. Based on the literature, seven common categories were identified which influenced the nature of involvement of physiotherapists in the weaning of mechanically ventilated patients. These were as follows:

- Demographics and ICU categorisation
- Weaning protocols
- Adjustment of mechanical ventilator settings
- Weaning and extubation
- Weaning interventions and physiotherapy modalities
- Physiotherapy autonomy
- Physiotherapist education

Each of these categories was discussed with the supervisor. Each category was broken down further as per available literature.

- Demographics and ICU categorisation
  - Number of years qualified
  - Role in hospital
  - Number of ICUs
ICU speciality
- Number of beds in ICU

Weaning protocols
- Is there a guideline or protocol currently in the unit?

Adjustment of mechanical ventilator settings
- Ventilation mode
- Ventilation respiratory rate
- Tidal volume
- Inspiratory pressure
- Pressure support
- PEEP
- FiO2

Weaning and extubation
- Decision to wean and extubate
- Performance of extubation

Weaning interventions and physiotherapy modalities
- Spontaneous breathing trials
- Non-invasive positive pressure ventilation
- Exercises prescribed (passive and active)

Physiotherapy autonomy

Physiotherapist education
- Qualifications
- Ongoing professional development

The questionnaire was piloted on the 11 January 2012 whereby a panel consisting of two senior cardiopulmonary physiotherapy lecturers and two physiotherapists who work in ICU on a daily basis, critically analysed each question in the questionnaire. Each member of the panel was emailed the questionnaire two weeks in advance so as to familiarise themselves with the purpose of the study as well as the individual questions. Suggestions and points of improvement were noted and the relevant changes were made.

The changes and corrections made from the pilot study included:
- Insertion of a questionnaire code ‘box’ for administration use to aid in statistical analysis.
- Change of questionnaire title to be more specific.
- Change of order and layout of the different ‘parts’ of the questionnaire to allow for a better flow.
- Spelling and grammar corrections.
• Additional questions were added regarding the number of physiotherapists working in ICU.
• A table was created combining information regarding the ICU speciality and number of beds per ICU.
• A question was added to determine who developed the weaning protocol.
• Additional physiotherapy interventions and modalities were added, namely, deep breathing exercises only, deep breathing exercises with biofeedback from ventilator, deep breathing exercises with adjustment of pressure support level, deep breathing exercises with patient connected to ambubag and deep breathing exercises against manual resistance. These suggestions were based on the clinical experience of the peer reviewers.

Once these changes were made, the questionnaire was again emailed to the panel members for confirmation of the corrections. In this way content validation of the questionnaire was achieved. See appendix III for a copy of the finalised questionnaire.

3.3.2 Data Collection Procedure
Identification of physiotherapists that fitted the inclusion criteria for the survey was done as outlined in section 3.2.1. Once consent was received from the heads of department of the public sector hospitals, practice owners at private hospitals as well as the chairperson of the CPRG, information sheets, instruction sheets and coded questionnaires were distributed to them.
For participants that requested these documents to be posted to them, the correct postal address was obtained as well as the total number of questionnaires required. Self return envelopes were provided to enable easy return of the questionnaires to the researcher. A courtesy call was given two to four weeks after postage to determine if the respective department and participants received the questionnaires and to remind participants to complete and return the questionnaire. For participants that requested the documents be emailed to them a list of email addresses was obtained. Thereafter an email with the link to the online survey and an information sheet were sent to each participant. A courtesy email was sent two to four weeks after the initial email to thank participants that had completed the online survey and remind those that had not.

The members of the CPRG were emailed the link to the online survey on behalf of the researcher by the national secretary of the CPRG. After four weeks, a reminder email was sent by the secretary to remind participants to complete the online survey and to thank those who had completed the survey. All participants were informed not to complete the survey if they had done so previously.
The process of contacting the public and private hospitals started on the 08 March 2012 until the 06 July 2012. Participants were given until the 16 January 2013 to either return the postal survey or complete the online survey.

All completed questionnaires received via post or the online survey were included in this survey and were analysed by the researcher and statistician.

3.4 ETHICAL CONSIDERATIONS
Ethical clearance for this study was granted by the Human Research Ethics Committee at the University of the Witwatersrand. The clearance certificate number is M110901 (see appendix I). Participation in the study was voluntary and no-one was penalized for not taking part in the study. All questionnaires were accompanied by an information sheet and consent sheet. The questionnaires were assigned a code to ensure anonymity. All completed and returned questionnaires were considered equivalent to consent obtained. The information sheet and consent sheet can be found in appendix II.

3.5 STATISTICAL ANALYSIS
Descriptive data analysis was used to analyse the data obtained from the questionnaires. Demographic information described by continuous parameters such as number of years qualified and number of years worked in ICU was summarized by using means, medians and standard deviations (SD). Demographic information described by categorical parameters such as work sector was summarised using frequencies and percentages. Fishers exact test and the Chi-squared test of independence was used to ascertain the involvement of physiotherapists in weaning in relation to the following variables: type of ICU, number of beds in the ICU, speciality of the ICU, number of years qualified and type of physiotherapy degree. Multinomial logistic regression was used to determine if the number of years physiotherapists were qualified for had an influence on their involvement in weaning. Percentages and frequencies were used to describe physiotherapists’ involvement in the development of weaning protocols, titration of ventilator settings, extubation and the common modalities used to facilitate respiratory muscle strengthening. These frequencies and percentages are presented in both text and in illustrative tables, pie charts and graphs. The STATA 11 statistics and data analysis software package was used for data analysis. A p-value of less than 0.05 was deemed statistically significant.

The results and analysis of the data collected during this study are presented in Chapter 4.
CHAPTER 4

4. RESULTS
This chapter describes the results obtained from the survey that was described in the previous chapter. Figures are used to present the study results for easier interpretation and understanding of the study outcomes. Standard deviations are rounded off to one decimal point and p-values to two decimal points.

A total of 425 questionnaires (n=425) were distributed among physiotherapists in South Africa who suited the inclusion criteria. Of the 425 questionnaires distributed, 200 questionnaires were sent via the postal system and 225 were sent via email with a link to the online survey. Of the 200 questionnaires sent via the postal system, n=109 were returned. The response rate for the postal questionnaires was therefore 54.5%. Of the 225 emails sent with the link to the online survey, n=75 were returned. The response rate for the online survey was 33.3%, resulting in a combined response rate of 43.3% (n=184).

4.1 STUDY POPULATION
The majority of the respondents were newly qualified physiotherapists (n=95). This is shown in figure 4.1

![Figure 4.1: Number of Years Qualified](image)

A large number of the respondents (n=113; 62%) worked in ICU between 1-5 years, followed by 22% (n=40) of physiotherapists with between 6-10 years experience in ICU. This is shown in Figure 4.2.
Figure 4.2: Number of Years Worked in ICU

The different roles of the respondents in the hospitals where they are employed are shown in Figure 4.3.

Figure 4.3: Role of Physiotherapist in Hospital

Majority of the respondents (n=79) were senior physiotherapists. The different sectors of employment of the respondents are summarized in Figure 4.4.
Figure 4.4: Sector of Employment

Most of the respondents (n= 120) worked in the public sector.

Figure 4.5 depicts the type of qualification that the respondents held.

Figure 4.5: Type of Physiotherapy Qualification

Majority (n=155) of the respondents had a Bachelor of Science degree in Physiotherapy. None held a Doctor of Philosophy qualification.

The mean number of ICUs per hospital was 3.2 (±SD 2.4).

Figure 4.6 depicts the speciality of ICU’s physiotherapists work in.
Figure 4.6: Speciality of ICU

The most common ICU speciality physiotherapists work in is the mixed medical, surgical and trauma ICU (n=126).

Table 4.1 shows the average number of beds per ICU.

### Table 4.1: Average Number of Beds per ICU Speciality

<table>
<thead>
<tr>
<th>ICU Speciality</th>
<th>Average number of beds</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical</td>
<td>9</td>
<td>3.23</td>
</tr>
<tr>
<td>Cardiovascular/Cardiothoracic</td>
<td>10</td>
<td>5.64</td>
</tr>
<tr>
<td>Trauma</td>
<td>14</td>
<td>7.99</td>
</tr>
<tr>
<td>Medical</td>
<td>10</td>
<td>3.79</td>
</tr>
<tr>
<td>Neurology</td>
<td>7</td>
<td>2.65</td>
</tr>
<tr>
<td>Burns</td>
<td>8</td>
<td>2.65</td>
</tr>
<tr>
<td>Mixed medical and surgical</td>
<td>12</td>
<td>6.29</td>
</tr>
<tr>
<td>Mixed medical, surgical and trauma</td>
<td>11</td>
<td>5.73</td>
</tr>
</tbody>
</table>

The average number of beds for any ICU speciality is 10 (±SD 5.54).

Table 4.2 shows the ICU type as per ICU speciality.
Table 4.2: ICU Type (Open or Close) as per ICU Speciality

<table>
<thead>
<tr>
<th>ICU Speciality</th>
<th>ICU ‘open’ type</th>
<th>ICU ‘close’ type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>Cardiovascular/Cardiothoracic</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>Trauma</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Medical</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td>Neurology</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Burns</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>Mixed medical and surgical</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>Mixed medical, surgical and trauma</td>
<td>72%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Most of the ICU’s are of the ‘open’ type meaning that it is non-specific physician led.

4.2 WEANING PROTOCOL

Thirty eight percent of physiotherapists (n=69) reported to have a guideline or protocol for weaning of patients from MV in their ICU. Of these physiotherapists, only 16% (n=11) were involved in the development of the weaning protocol. Majority of the remaining physiotherapists (n=51, 74%) reported to not be involved in the development of a weaning protocol for their ICU.

Figure 4.7 represents the various health care professionals that were involved in the development of weaning protocols for the various ICUs.
Figure 4.7: Health Care Professionals Responsible for Developing the Weaning Protocol

Seventy two percent of physiotherapists (n=50) indicated that medical practitioners were mostly involved in the development of weaning protocols in their ICUs with 22% (n=15) reporting that a multidisciplinary team of medical practitioners, nursing staff and clinical facilitators were involved in the development of weaning protocols. Clinical facilitators are trained registered nurses who have critical care and ICU experience and are often involved in the training and development activities in their ICUs.

4.3 ADJUSTMENT OF MECHANICAL VENTILATOR SETTINGS

Figure 4.8 indicates how often physiotherapists make adjustments to mechanical ventilator settings for the purposes of respiratory muscle training to assist patients with weaning from MV.

![Ventilator Setting Adjustment Graph]

Figure 4.8: How often do Physiotherapists Adjust Ventilator Settings

Majority of the physiotherapists (>80%; n=154) ‘never' adjust the ventilator settings related to ventilator mode, respiratory rate, tidal volume, inspiratory pressure and PEEP on the mechanical ventilator. It appears that physiotherapists are more involved in adjusting the FiO$_2$ on the mechanical ventilator. This is reflected by 11% reporting that they ‘routinely' adjusted FiO$_2$, 10% reported they ‘often' make this adjustment and 14% reported that they ‘frequently' adjust FiO$_2$. 
With regards to physiotherapists giving advice and input to the adjustment of mechanical ventilator settings (to facilitate weaning), Figure 4.9 represents the adjustments of the mechanical ventilator settings as a result of physiotherapy advice to the ICU team.

**Figure 4.9: How Often do Physiotherapists Give Advice to Adjust Ventilator Settings**

Majority of the physiotherapists never give advice to adjust the mechanical ventilator settings related to ventilation mode, RR, TV, inspiratory pressure, PS and PEEP. With regards to FiO₂, it is apparent that physiotherapists are more confident in providing advice to titrate FiO₂ as a combined 32% reports to advise the staff to adjust FiO₂ either frequently, often or routinely.

### 4.4 WEANING AND EXTUBATION

Figure 4.10 represents the involvement of physiotherapists in the decision to start weaning a patient from MV.
Figure 4.10: Physiotherapist involved in the Decision to Start Weaning

Seventy six percent of (n=135) of physiotherapists never or seldom get involved in the decision to start weaning a patient from MV. Fourteen percent (n=25) of physiotherapists reported that they frequently get involved and only five percent of physiotherapists (n=8) reported they are involved routinely and often respectively.

With regards to extubation 36% (n=63) of the respondents reported to never get involved in decision making to extubate a patient on MV and 28% (n=50) reported that they seldom get involved. This indicates that majority of the physiotherapists seldom or never provides advice to extubate a patient. Fifty five percent (n=96) of the respondents indicated that they never extubate patients from MV, followed by 15% (n=26) that seldom do. Sixteen percent (n=28) of physiotherapists perform extubations routinely.

What is interesting to note is that 36% (n=63) of respondents were involved in the decision making to extubate either frequently, often or routinely and 31% (n=54) were involved in the actual extubation frequently, often or routinely. This is reflected in Figure 4.11.

Figure 4.11: Physiotherapists Involvement in Extubation

This implies that if physiotherapists were involved in the decision making to extubate a patient from MV, they were more likely to perform the extubation.
4.5 **WEANING INTERVENTIONS**

Physiotherapists were asked if they performed weaning interventions such as SBT and NIV. Results are summarised in Figure 4.12 below.

![Figure 4.12: Weaning Interventions Performed by Physiotherapists](image)

**Figure 4.12:** Weaning Interventions Performed by Physiotherapists

Majority of the physiotherapists (67%, n=119) never used a SBT to facilitate weaning of a patient off MV. Similarly majority of the physiotherapists never used NIV (58%, n=101). Although only a very small percentage (16%) uses NIV frequently, often or routinely, it appears that more physiotherapists use NIV compared to SBTs, however this was statistically insignificant (p=0.41).

4.6 **PHYSIOTHERAPY MODALITIES TO FACILITATE RESPIRATORY MUSCLE STRENGTHENING**

The physiotherapists were asked which modalities they used to facilitate respiratory muscle strengthening of a patient to assist weaning from MV. Their responses are shown in Figure 4.13.
Eighty one percent (n=138) of the respondents used exercises routinely in the form of auto assisted and active exercises to aid in respiratory muscle training. Seventy seven percent (n=134) of the respondents used early mobilisation out of bed and DBE only routinely respectively. The fourth most common modality used routinely by physiotherapists (30%, n=52) was DBE against manual resistance.

The modalities that were not used as often are DBE with biofeedback from the ventilator, DBE with adjustment of PS levels and DBE with MHI. The most common modality ‘never’ used by physiotherapists to strengthen respiratory muscles was DBE with adjustment of PS (68%, n=117). This is in keeping with majority of physiotherapists (77%, n=134) who reported to ‘never’ adjust the PS setting on the ventilator.

4.7 PHYSIOTHERAPY AUTONOMY

Physiotherapy autonomy was defined as the ability of the physiotherapist to make decisions regarding weaning of a patient from MV in the unit where they work and implementation of the decision without direct supervision from a medical colleague. Physiotherapists were
asked to rate physiotherapy autonomy with regards to MV in their unit. Responses were recorded on a Likert type scale. A mean rate of 1.9 (±SD 1.6) was calculated whereby ‘1’ correlated to no autonomy and ‘10’ to complete autonomy. When asked how often do physiotherapists’ contributions influence decisions regarding MV in their unit, a mean rate of 2.9 (±SD 2.2) was recorded. On this scale, ‘1’ correlated to never and ‘10’ always.

4.8 CONTINUOUS PROFESSIONAL DEVELOPMENT

Physiotherapists were asked whether opportunities were available within their working environment (internal) and outside their working environment (external) for continuous professional development related to MV. Figure 4.14 displays the results.

![Figure 4.14: Continuous Professional Development (CPD) and Mechanical Ventilation (MV)](image)

Interestingly majority (45%, n=77) of physiotherapists do have opportunities for CPD within their work environment in the form of in service training. Fifty eight percent (n=99) of physiotherapists reported that there were opportunities for external CPD related to MV. These percentages however do not indicate if physiotherapists attend these training sessions as it is clear that majority of physiotherapists are not involved in the weaning of mechanically ventilated patients. Ninety eight percent (n=168) of physiotherapists reported to be keen to attend future training sessions with regards to the role of physiotherapy in the management of mechanically ventilated patients to prepare them for weaning and extubation.

4.9 CORRELATION OF DATA VARIABLES

The Chi-squared test of independence and Fisher test were used to determine significance between variables. The variables analysed were whether the number of beds in ICU, type of ICU, ICU speciality, number of years physiotherapists are qualified for and type of
physiotherapy degree had an influence on the physiotherapists’ involvement in the weaning of patients from MV. In addition multinomial logistic regression was used to determine if the number of years physiotherapists are qualified for have an influence on the physiotherapists’ involvement in weaning. It was found that there is no association between the exploratory variables.

Table 4.3 shows the ‘p’ values for the exploratory variables of ICU speciality, number of beds and type of ICU when compared to physiotherapists’ involvement in weaning of patients from MV.

Table 4.3: Factors that may Influence Physiotherapists’ Involvement in Weaning of Patients from MV

<table>
<thead>
<tr>
<th></th>
<th>ICU speciality ‘p’ value</th>
<th>Number of beds ‘p’ value</th>
<th>ICU type ‘p’ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical</td>
<td>0.26</td>
<td>0.16</td>
<td>0.24</td>
</tr>
<tr>
<td>Cardiovascular/Cardiothoracic</td>
<td>0.11</td>
<td>0.13</td>
<td>0.97</td>
</tr>
<tr>
<td>Trauma</td>
<td>0.06</td>
<td>1.00</td>
<td>0.21</td>
</tr>
<tr>
<td>Medical</td>
<td>0.06</td>
<td>0.09</td>
<td>0.95</td>
</tr>
<tr>
<td>Neurology</td>
<td>0.45</td>
<td>0.52</td>
<td>1.00</td>
</tr>
<tr>
<td>Burns</td>
<td>0.15</td>
<td>0.83</td>
<td>0.43</td>
</tr>
<tr>
<td>Mixed medical and surgical</td>
<td>0.46</td>
<td>0.74</td>
<td>1.00</td>
</tr>
<tr>
<td>Mixed medical, surgical and trauma</td>
<td>0.35</td>
<td>0.81</td>
<td>0.11</td>
</tr>
</tbody>
</table>

The results show no association between ICU speciality, ICU type and number of beds to physiotherapists’ involvement in the weaning of mechanically ventilated patients.

Figure 4.15 is a 100% stacked area graph depicting the relationship between the number of years physiotherapists are qualified for and the involvement of physiotherapists in weaning.
Figure 4.15: Physiotherapist involvement in Weaning of MV in Relation to Number of Years Qualified

There is no association between the number of years physiotherapists are qualified for and physiotherapists involvement in weaning (p=0.43). According to the multinomial logistic regression, it does appear that physiotherapists qualified for greater than 11 years are more involved in the weaning of mechanically ventilated patients. This is depicting in figure 4.15 showing that physiotherapists qualified for greater than 11 years are more involved in the weaning of mechanically ventilated patients on a frequent, often and routine basis. This implies that with experience, physiotherapists are more confident to get involved in the weaning of mechanically ventilated patients.

There is no association between the type of physiotherapy degree to the physiotherapists involvement in weaning (p=0.24).

The results obtained through this survey are discussed in Chapter 5.
CHAPTER 5

5. DISCUSSION

The main finding of this survey was that the majority of physiotherapists in South Africa who work in ICU are not involved in the weaning of mechanically ventilated patients. This is in contrast to international practice whereby in Canada and the USA, respiratory therapists play a major role in weaning from MV (Blackwood et al. 2009). In countries such as UK, Europe and Australia cardiorespiratory physiotherapists are actively involved in the weaning of patients from MV (Hannan et al. 2013; Carpene et al. 2010; Blackwood et al. 2009; Chang et al. 2005; Bruton and Mc Pherson 2004). Although South Africa does not have respiratory therapists the scope of practice of physiotherapists in ICU is similar to that of physiotherapists in the UK, Australia and New Zealand. Therefore the results of this survey regarding the lack of physiotherapists’ involvement in weaning of patients from MV is concerning.

In Australia, Hannan et al. (2013) applied the use of a weaning protocol to a specialised weaning unit according to a model of care similar to that employed in specialised units in the UK and Europe. This was the first of its kind in Australia where the authors sought to examine the inpatient and long-term outcomes of patients admitted to a specialised weaning unit. Secondary aims were to identify factors that influenced weaning success, inpatient and long-term mortality. The approach to weaning was multidisciplinary and it included cardiorespiratory physiotherapists. The researchers employed active measures to optimise medical status, enhance sputum clearance and improve sleep–wake cycle. Physical therapy was implemented to maintain or improve peripheral muscle strength. Ventilation was undertaken predominantly in assist-control modes to improve sleep quality with weaning generally consisting of progressive SBTs during waking hours. Non-invasive ventilation was used selectively both as a bridge to spontaneous breathing and to support those who required ongoing nocturnal ventilatory support (Hannan et al. 2013). Studies by Carpene et al. 2010, Blackwood et al. 2009 and Chang et al. 2005 detail the outcomes in specialised weaning centres in the United States, UK and Europe and have reported wide variations in weaning success (38%–77%) and inpatient mortality (10–47%). The study by Hannan and colleagues achieved a weaning success rate of 78% with a low in-patient (10%) mortality and thus compared favourably with those reported internationally (Hannan et al. 2013). Seventy four percent of South African physiotherapists report to not be involved in the development and implementation of weaning protocols in their ICUs. It is thus a concern that South African physiotherapy practice does not compare favourably with international practice. These international studies reported improved weaning success and
decreased patient mortality as a result of the use of weaning protocols and therefore it would be beneficial to patient outcome if this intervention is included in daily practice in South Africa ICUs.

In a recent literature review conducted by White et al (2011), the authors sought to determine if ventilation-weaning protocols developed and implemented by multidisciplinary teams, including physiotherapists, reduced the duration of MV. The results highlighted that protocolised care for weaning continues to improve patient outcomes, contain costs and limit resources used in ICUs. In addition the results support the use of multidisciplinary team developed and implemented weaning protocols to reduce duration of MV. So given that different countries, hospitals and ICUs have different patient characteristics, ventilatory technologies, models of clinical management, staff profiles and resources, it is accepted that the approach to weaning should be multidisciplinary, involving respiratory physicians, specialized respiratory nurses, cardiorespiratory physiotherapists, dieticians/nutritionists and ICU/hospital directors (Hannan et al 2013; White et al 2011; Tonnelier 2005). In a study conducted in South Africa, it was found that a nurse and physiotherapy led weaning and extubation protocol resulted in a clinically significant reduction in MV time thus reducing the risk of ventilator associated complications (Plani et al 2012).

It is thus a concern that physiotherapists in South Africa are not in line with international physiotherapy practice with regards to weaning according to the literature. With regards to the development and implementation of weaning protocols a small percentage of South African physiotherapists had a weaning protocol in their unit and of these, only 16% were involved in the development of the protocol. What is interesting to note is that of the 16% of physiotherapists that were involved in the development of the weaning protocol, majority reported to follow the protocol in their unit. This is in keeping with the literature that supports the role of a physiotherapist in the development of weaning protocols. If physiotherapists are involved in the development of the weaning protocol, they are more likely to be involved in its implementation (White et al 2011). The results of this study further show that in South Africa, medical practitioners most commonly assume the role of developing weaning protocols.

With regards to weaning methods, the most commonly used, as reported earlier in the literature review chapter, are intermittent T-piece trials, SIMV involving gradual reductions in the ventilator rate, PSV involving the gradual reduction of inspiratory pressure or spontaneous breathing through the ventilator circuit with the application of CPAP (Blackwood et al 2011). The results of the current study show that majority of physiotherapists in South Africa never adjust the ventilator settings or provide advice to
fellow health care professionals to titrate ventilation to facilitate weaning. The ventilator setting most commonly adjusted by physiotherapists is FiO$_2$. The possible reason for this is that prior to suctioning, a physiotherapy technique performed commonly on ventilated patients, the FiO$_2$ must be increased to 100% and then decreased to the original setting post suctioning. In addition during physiotherapy treatment, if a patients’ saturation level decreases, physiotherapists often titrate the FiO$_2$ to ensure adequate oxygenation and patient comfort. This technique is part of undergraduate training and this fact in addition to increase confidence and use of titrating FiO$_2$ may be a reason why it is the most common ventilator setting adjusted by physiotherapists.

Ely et al (2001) recommended that SBTs can be performed safely by non-physician health care providers using a T-piece, CPAP without PS, or with PS up to 7 cm H$_2$O, and for durations of 30 minutes to two hours. The monitored assessment of spontaneous breathing should be conducted at least once daily and should be integrated with other major events in the patient’s daily care, including the cessation or temporary reduction in delivery of sedation and analgesic medications. Majority of the physiotherapists in South Africa seem not to be involved in SBTs as 67% never use SBTs and a further 20% seldom use it.

With regards to NIV, Trevisan and Vieira (2008) and Bruton et al (1999) reported that it can be used as a weaning adjunct and its institution and maintenance can be performed by physiotherapists, particularly when this form of ventilation is continued beyond the ICU. They further reported that it appears to be a natural extension of physiotherapy skills as physiotherapists often use Intermittent positive pressure breathing (IPPB) systems (e.g. the Bird). The results of a study by Trevisan and Vieira (2008) suggested that the combination of early extubation and NIV is a good alternative for ventilation in a group of heterogeneous patients who initially failed weaning. Non-invasive ventilation resulted in efficient gas exchange, a tendency to decrease ICU and hospital stays and a reduction in the incidence of VAP as well as the need for tracheostomy when compared with conventional invasive MV weaning. Therefore NIV is a useful, safe and supported strategy that may be considered during MV weaning. In South Africa however, majority of the physiotherapists do not use this intervention to facilitate weaning of patients from MV. A possible explanation for the lack of use of SBTs and NIV is that not all universities in South Africa provide undergraduate training on the administration of NIV and SBTs to physiotherapists. Therefore these interventions may be deemed ‘out of the scope’ of South African physiotherapy practice. Non-invasive ventilation and SBT application is traditionally more the responsibility of medical doctors in South Africa.
In critically ill patients, a prolonged hospital stay, due to the initial acute insult and adverse side-effects of drug therapy, may cause severe late complications, such as muscle weakness, prolonged symptoms, mood alterations and poor health-related quality of life (Ambrosino et al 2012; Carpene et al 2010). As with other skeletal muscles, the ventilatory pump may also be profoundly altered by these factors. Interventions aimed at increasing inspiratory volume (DBE, mobilisation and body positioning) may affect lung expansion, increase regional ventilation, reduce airway resistance and optimise pulmonary compliance. Manual hyperinflation or ventilator hyperinflation, PEEP ventilation, postural drainage, chest wall compression and airway suctioning may assist in clearance of secretions (Gosselink et al 2011).

The results from this survey showed that 81% of physiotherapists use exercises in the form of active-assisted and active exercises as a treatment modality to facilitate respiratory muscle strengthening followed by 77% who routinely use DBE and early mobilisation out of bed.

Gosselink et al (2011) reported that mobilisation has been part of the physiotherapy of acutely ill patients for several decades. Mobilisation refers to physical activity sufficient to elicit acute physiological effects that enhance ventilation, central and peripheral perfusion, circulation, muscle metabolism and alertness. Standing and walking frames enable the patient to mobilise safely with attachments for bags, lines and leads that cannot be disconnected. The frame either needs to be able to accommodate a portable O2 tank, or a portable mechanical ventilator and seat, or a suitable trolley for equipment can be used. Walking and standing aids enhance physiological responses and promote early mobilisation of critically ill patients (Gosselink et al 2011; Clin and Ambrosino 2005).

Based on the results of this study, majority of South African physiotherapists use early mobilisation routinely and this compares favourably with international practice.

The removal of the artificial airway from a patient who has successfully been discontinued from ventilatory support should be based on assessments of airway patency and the ability of the patient to protect the airway (MacIntyre et al 2001). Physiotherapists should be actively involved in the assessment of cough strength and amount of secretions of any patient prior to extubation in order to ensure sound decision making by the ICU team (Vivar and Esterban 2003).

In South Africa, extubation is within the scope of physiotherapy practice and is often performed with the assistance of the ICU nursing staff. However the results from this survey
show that about two thirds of the respondents reported to seldom or never get involved in decision making to extubate. This indicates that the majority of the physiotherapists seldom or never provide advice to extubate. Majority of the respondents indicated that they never extubate patients from MV, followed by a small percentage that seldom do. This shows that majority of physiotherapists who participated in this survey played no role in extubating patients from MV. In a pilot study conducted by Van Aswegen and Potterton (2005), the investigators reported that 65% of physiotherapists in South Africa perform extubations. This is in contrast to this study. A possible reason for this is that in this study, majority of the respondents were qualified for less than five years and thus their lack of experience may have a negative impact on their confidence to perform extubation.

When comparing whether the number of years physiotherapists are qualified for have an influence on physiotherapists' involvement in weaning, there was no association. However, according to the multinomial logistic regression, it does appear that physiotherapists qualified for more than 11 years are more involved in the weaning of mechanically ventilated patients. Perhaps with clinical experience, physiotherapists enhance their confidence and clinical skills and thus become more involved in weaning of mechanically ventilated patients.

In addition there was no association reported between the number of beds in ICU and the type of ICU on the physiotherapists’ involvement in weaning of mechanically ventilated patients.

5.1 LIMITATIONS OF THE CURRENT STUDY
The study was limited by the poor response rate from the physiotherapists in South Africa that work in ICU, specifically those that work in the private sector. The reason for this could be that private physiotherapists may have more administration responsibilities and thus did not deem the survey as a priority to complete.

Extensive research was performed to determine the effect of IMT on weaning of mechanically ventilated patients. The literature is in support of this modality, however, this questionnaire did not include a question to determine if physiotherapists in South Africa use this modality to aid in the weaning of mechanically ventilated patients.

5.2 RECOMMENDATIONS FOR FUTURE STUDIES
a) Future surveys should address the reasons as to why physiotherapists are not involved in the weaning of mechanically ventilated patients. This will help to bridge the gap between local and international practice with regards to weaning.
b) University lecturers should be approached to determine if MV and specifically weaning of patients from MV is adequately and appropriately part of undergraduate curriculum training.

c) As 98% of the physiotherapists agreed to attend future training sessions with regards to MV, it is of importance that workshops and seminars be arranged to address this issue. A survey that assesses change in physiotherapy behaviour regarding their involvement with weaning and extubation of patients after such workshops/seminars could be performed.

d) Medical practitioners, physicians and nurses should be interviewed to determine their views on the multidisciplinary team development and implementation of weaning protocols. It could be that their apprehension to such an intervention may limit physiotherapist involvement in the weaning of mechanically ventilated patients.
CHAPTER 6

6. CONCLUSION

This survey of 184 physiotherapists working in adult ICUs across South Africa revealed that physiotherapists are not actively involved in the weaning of mechanically ventilated patients. Majority of the respondents were junior physiotherapists and thus this lack of experience may be a contributing factor to the lack of involvement in the weaning of mechanically ventilated patients.

Majority of the physiotherapists reported that the ICU units they work in do not have a weaning protocol. For the minority of physiotherapists that do have weaning protocols in their ICUs, majority of them were not involved in the development of the protocols. Medical practitioners were reported to be primarily responsible for this role. With regards to adjustments and titration of mechanical ventilator settings to facilitate weaning, physiotherapists in South Africa do not give advice or input to fellow ICU health care providers. Physiotherapists do not get involved in the adjustment of the ventilator mode, RR, VT, inspiratory pressure, PS and PEEP. The setting most commonly adjusted by physiotherapists is FiO₂.

Physiotherapists report to never get involved in the application of SBTs or NIV as a weaning modality. In addition, they do not perform extubation. What is a more common practice is the application of exercise therapy, DBE and early mobilisation out of bed. The modalities that were not used as often are DBE with biofeedback from the ventilator, DBE with adjustment of PS levels and DBE with MHI. The most common modality ‘never’ used by physiotherapists to strengthen respiratory muscles was DBE with adjustment of PS.

This survey showed that the practice of physiotherapists in South Africa with regards to weaning is in contrast to international practice. Physiotherapists rated their autonomy poorly with regards to their influence on weaning from MV in their ICUs. They feel they do not have the ability to make MV decisions regarding weaning and implement them without direct supervision of a medical colleague. They further reported a keen interest in future training sessions on the management of mechanically ventilated patients. This is highly recommended to bridge the gap of local and international practice.
REFERENCES


Plani, N, Becker P, Van Aswegen, H, ‘The use of a weaning and extubation protocol to facilitate effective weaning and extubation from mechanical ventilation in patients suffering from traumatic
injuries: A non-randomized experimental trial comparing a prospective to retrospective cohort’, *Physiotherapy Theory and Practice*, vol. 29, pp 211 – 221.


APPENDIX I

ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49  Miss Dipna Morar

CLEARANCE CERTIFICATE  M110901

PROJECT
The Nature of Involvement of Physiotherapist in South Africa in the Weaning Process of Mechanically Ventilated Patients

INVESTIGATORS
Miss Dipna Morar

DEPARTMENT
Department of Physiotherapy

DATE CONSIDERED
30/09/2011

M1109010DECISION OF THE COMMITTEE*
Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE  25/11/2011  CHAIRPERSON (Professor PE Cleaton-Jones)

*Guidelines for written ‘informed consent’ attached where applicable
/cc: Supervisor: Dr Heleen van Aswegen

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and ONE COPY returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress report.
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...
Dear Participant.

I, Dipna Morar, am registered as a postgraduate student at the University of the Witwatersrand. I am investigating the involvement of South African physiotherapists in the weaning of mechanically ventilated patients, as part of a Masters degree.

Research done in Canada, the United States of America and the United Kingdom suggest that physiotherapists, in particular respiratory therapists, do have a crucial role in the weaning of mechanically ventilated patients.

Some benefits of physiotherapists’ involvement with such patients include decreased length of ICU stay, decreases risk of ventilator associated pneumonia and a decrease in the duration of mechanical ventilation as a result of rehabilitation provided in ICU. Thus far, no literature has been found depicting the involvement of South African physiotherapists in the weaning of mechanically ventilated patients.

The aim of this study is to determine the involvement of South African physiotherapists in the weaning of mechanically ventilated patients. By participating in this study, you will aid in the better understanding of the current physiotherapy practice in the weaning of mechanically ventilated patients and will influence future management of critically ill patients in South Africa.

A self-administered questionnaire enclosed will need to be completed. All questionnaires are anonymous and all information obtained will remain confidential. The questionnaire takes 10-15 minutes to complete. You will not have to incur any expenses as the questionnaire will either be completed electronically or returned using the self return envelopes provided. Please complete and sign the consent form below. All completed and returned questionnaires will be considered equivalent to consent obtained.

For further information regarding the study or if any of the above information is unclear to you, please do not hesitate to contact me.

Contact person: Dipna Morar
Contact number: (011) 852 – 8690 or 072 212 7182
dm.physio4you@gmail.com
CONSENT

I fully understand the nature of this study investigating the involvement of South African physiotherapists in the weaning of mechanically ventilated patients.
I agree to participate in this study by completing the questionnaire provided.

Name : _____________________________________________
Signature : __________________________________________
Date : _____________________________________________
APPENDIX III

SURVEY OF RESPONSIBILITIES OF PHYSIOTHERAPISTS IN SOUTH AFRICA IN RELATION TO WEANING FROM MECHANICAL VENTILATION

Part A: DEMOGRAPHICS AND ICU CATEGORISATION

1. How many years have you been qualified for?
   - 1-5
   - 6-10
   - 11-15
   - 16+

2. What is your role in the hospital you work in?
   - Junior physiotherapist (<3 years experience)
   - Senior physiotherapist (>3 years experience)
   - Head of department
   - Practice owner

3. How many years have you been working in ICU?
   - 1-5
   - 6-10
   - 11-15
   - 16+

4. Please identify the type of hospital you work in on a full time basis
   - Public hospital
   - Private hospital

5. Number of ICUs in the hospital __________

6. Please identify the primary speciality of your ICU and the number of beds per ICU and whether it is a closed (intensivists lead) or open (non-specific physician lead)

<table>
<thead>
<tr>
<th>Speciality of ICU</th>
<th>Number of beds in this ICU</th>
<th>ICU type, i.e. closed or open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular/Cardiothoracic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td></td>
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</tr>
<tr>
<td>Neurology</td>
<td></td>
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<tr>
<td>Burns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed medical and surgical</td>
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<tr>
<td>Mixed medical, surgical and trauma</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. If you work in the government sector, how many physiotherapists work with you in the ICU? ____________________________________________________________
8. If you work in the private sector:
   a. How many practices provide a service to your ICU?__________________________
   b. How many physiotherapists work under your practice in the ICU?_______________

Part B: WEANING PROTOCOL
1. In your ICU, do you have a guideline/policy/protocol for the weaning of patients from mechanical ventilation (MV)?
   ő Yes                         ő No                         ő Uncertain
   *If you answered No to the above question proceed to Part C*

2. If Yes, were you as a physiotherapist involved in the development of the weaning protocol?
   ő Yes                         ő No                         ő Uncertain

3. If No, who developed the weaning protocol?
   ő Medical practitioners       ő Nursing staff
   ő Clinical facilitators       ő All of the above

4. If you were involved in the development of the weaning protocol, do you as a physiotherapist follow the weaning protocol?
   ő Yes                         ő No                         ő Uncertain

Part C: ADJUSTMENT OF MECHANICAL VENTILATOR SETTINGS
1. How often do you as a physiotherapist make or implement the following decisions:

<table>
<thead>
<tr>
<th>Decision</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Adjust the ventilation mode</td>
<td>ő</td>
<td>ő</td>
<td>ő</td>
<td>ő</td>
<td>ő</td>
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<tr>
<td>2. Adjust ventilation respiratory rate</td>
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<td>ő</td>
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<tr>
<td>3. Adjust tidal volume</td>
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<tr>
<td>4. Adjust inspiratory pressure</td>
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<td>5. Adjust pressure support</td>
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<td>ő</td>
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<tr>
<td>6. Adjust PEEP (positive end expiratory end pressure)</td>
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<td>ő</td>
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<tr>
<td>7. Adjust FiO₂ (Frequency of inspired oxygen)</td>
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<td>ő</td>
</tr>
</tbody>
</table>
2. How often do you as a physiotherapist give advice and input to the following decisions:

<table>
<thead>
<tr>
<th>Decision</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
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<tbody>
<tr>
<td>1. Adjust the ventilation mode</td>
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<tr>
<td>2. Adjust ventilation respiratory rate</td>
<td>☐</td>
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<tr>
<td>3. Adjust tidal volume</td>
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<tr>
<td>4. Adjust inspiratory pressure</td>
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<tr>
<td>5. Adjust pressure support</td>
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<td>☐</td>
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<tr>
<td>6. Adjust PEEP (positive end expiratory end pressure)</td>
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<tr>
<td>7. Adjust FiO₂ (Frequency of inspired oxygen)</td>
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Part D: WEANING AND EXTUBATION

1. How often are you involved in the decision making to start weaning from MV?

<table>
<thead>
<tr>
<th>Decision</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
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</tbody>
</table>

2. How often are you involved in deciding if a patient is ready to be extubated?

<table>
<thead>
<tr>
<th>Decision</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
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</table>

3. Do you extubate patients from MV?

<table>
<thead>
<tr>
<th>Decision</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
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</table>

Part E: WEANING INTERVENTIONS AND PHYSIOTHERAPY MODALITIES

1. Are you as a physiotherapist involved in any of the following weaning interventions?

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spontaneous Breathing Trails</td>
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<td>2. Non-invasive positive pressure ventilation</td>
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</table>
2. Are you as a physiotherapist involved in any of the following physiotherapy modalities?

<table>
<thead>
<tr>
<th>Exercise Type</th>
<th>Never (0%)</th>
<th>Seldom (1-25%)</th>
<th>Frequently (26-50%)</th>
<th>Often (51-75%)</th>
<th>Routinely (&gt;75%)</th>
<th>Uncertain</th>
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</thead>
<tbody>
<tr>
<td>1. Exercises (auto-assisted and active)</td>
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<td>2. Early mobilisation out of bed</td>
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<td>3. Deep breathing exercises (DBE) only</td>
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<td>4. DBE with biofeedback from ventilator</td>
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<td>5. DBE with adjustment of pressure support levels</td>
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<td>6. DBE with patient connected to an ambubag</td>
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<td>7. DBE against manual resistance</td>
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</tbody>
</table>

Part F: PHYSIOTHERAPY AUTONOMY

1. How would you rate physiotherapy autonomy in your ICU with regards to MV? Please circle the number on the scale below

   For the purpose of this study, ‘autonomy’ will be defined as the ability to make ventilation decisions regarding weaning and implement them without direct supervision of a medical colleague.

   No Autonomy | Complete Autonomy
   1 2 3 4 5 6 7 8 9 10

2. How often do physiotherapists’ contributions influence decisions made regarding MV in your ICU? Please circle the number on the scale below

   Never | Always
   1 2 3 4 5 6 7 8 9 10

Part G: PHYSIOTHERAPIST EDUCATION

1. What is the highest degree that you currently hold?

   - Diploma in Physiotherapy
   - MSc (Masters in Physiotherapy)
   - BSc (Bachelor of Science)
   - PhD (Doctor of Philosophy)
2. Are opportunities available in your working environment for ongoing professional development related to mechanical ventilation?
   ☐ Yes ☐ No ☐ Uncertain

3. Are opportunities available for your on-going professional development, outside your working environment, related to mechanical ventilation?
   ☐ Yes ☐ No ☐ Uncertain

4. If training sessions are made available with regard to physiotherapy in the management of mechanically ventilated patients, would you attend?
   ☐ Yes ☐ No ☐ Uncertain

THANK YOU for taking the time to complete the questionnaire.