



## EFFECT OF INSPIRATORY MUSCLE TRAINING: A CASE REPORT

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### Abstract:

**Background and Purpose:** Inspiratory muscle weakness and fatigue has been documented following prolonged mechanical ventilation despite successful weaning from mechanical ventilation. This report describes the application of inspiratory muscle training in two patients following successful discharge from an intensive care unit (ICU) after prolonged mechanical ventilation.

**Methods:** Both patients undertook inspiratory muscle training in conjunction with standard physiotherapy rehabilitation.

**Results:** Improvements in inspiratory muscle strength and endurance, exercise tolerance and functional performance following twice-daily inspiratory muscle training were recorded. In both cases, an improvement in maximal inspiratory pressure (MIP) and maximal tolerated inspiratory load (MIP load) was found following training.

**Conclusion:** These positive results indicate further research is needed to investigate the effect of inspiratory muscle training on respiratory function, exercise tolerance and functional performance, for the possible inclusion of inspiratory muscle training into the physiotherapy management of patients following prolonged mechanical ventilation.

**Keywords:** Rehabilitation, inspiratory muscle training, case report

## INTRODUCTION

Difficulty in weaning from mechanical ventilation is a common reason for the prolonged ICU admission in this population, and recent studies have proposed the use of inspiratory muscle training (IMT) to facilitate weaning in these patients. Although preliminary studies have demonstrated successful weaning in the majority of cases (Martin et al., 2002), respiratory muscle weakness may be present at the end of the training programme.

Weakness after successful weaning from mechanical ventilation has been demonstrated by Sprague and Hopkins (2003), who found that after completion of IMT the average maximal inspiratory pressure (MIP) achieved was -54 cm H<sub>2</sub>O with subjects able to sustain a pressure of 27.5 cm H<sub>2</sub>O for six to eight breaths. This suggests significant weakness of the respiratory muscles, as based on the normative data (Black and Hyatt, 1969); we calculated MIP for these patients to be 52 cm H<sub>2</sub>O (12%) of predicted values after IMT and successful weaning from mechanical ventilation. This suggests that, despite successful

weaning and probable discharge from intensive care, chronic critically ill patients may have persistent inspiratory muscle weakness that requires specific rehabilitation in the post-ICU period. Similarly, earlier findings demonstrate that inspiratory muscle endurance is reduced after prolonged mechanical ventilation

(Chang et al., 2005). Therefore, individuals who have experienced prolonged periods of mechanical ventilation, despite successful weaning and discharge from intensive care, are likely to continue to have weakness and poor endurance of the inspiratory muscles. This Case Report describes the introduction of inspiratory threshold training to the physiotherapy management of two chronic critically ill patients who were successfully weaned and discharged from the ICU.

## CASE DESCRIPTIONS

### Case 1

Mr A was a 73-year-old man who was admitted with respiratory failure following bilateral pneumonia. His

medical history included chronic obstructive pulmonary disease, obstructive sleep apnoea, ischemic heart disease and non-insulin-dependent diabetes. He was admitted to the ICU for 53 days, of which he was mechanically ventilated for 50.6 days. On discharge from ICU Mr A had a tracheostomy *in situ* for 14 days before decannulation.

## Case 2

Mr B was a 77-year-old man who was also admitted with respiratory failure resulting from bullous lung disease and empyema. He had no other significant previous medical history and spent 46 days in ICU, requiring mechanical ventilation for 20.4 days. He also required a tracheostomy for three days after discharge from the ICU.

Neither patient had signs of critical illness polyneuropathy as demonstrated by nerve conduction studies. Inspiratory muscle strength and endurance were measured before commencing the IMT component of the physiotherapy management. Inspiratory muscle strength was measured by maximal inspiratory pressure (MIP) at residual volume (ATS, 2002a). A marker of inspiratory muscle endurance was measured using a method outlined by Martin et al. (2002), in which subjects inspired through an inspiratory threshold trainer (Threshold TM, Mayo Healthcare) for six to eight breaths and the perceived exertion was recorded on a 10- point scale. The load was progressively increased, with rests in between, until the subject reported a Borg score between 6 and 8 on the scale, and recorded this as MIP load.

Before the IMT training, Mr A had a MIP of  $-83.8$  cm H<sub>2</sub>O, within normal limits, but his endurance was impaired, and with the MIP load achieved  $-16$  cm H<sub>2</sub>O. Mr B demonstrated severe inspiratory muscle weakness, a MIP of  $-16$  cm H<sub>2</sub>O, only 15% of predicted, and achieved a MIP load of  $-28$  cm H<sub>2</sub>O. These values for MIP load are similar to those reported by previous authors for chronic critically ill patients who have difficulty weaning from mechanical ventilation (Martin et al., 2002; Sprague and Hopkins, 2003). Measures of exercise tolerance and

performance in activities of daily living (ADL) were also recorded prior to the IMT. The distance walked in six minutes (6MWD) was measured, according to American Thoracic Society guidelines (ATS, 2002a), and Mr A was able to walk 163 m, whereas Mr B was not able to walk

independently before training, resulting in a 6MWD of 0 m. A Katz ADL scale (Katz et al., 1963) was used to record independence in daily tasks such as bathing, dressing, feeding, transfers, toileting and continence. Mr A was given a score of B, indicating independence in all but one of the above, and Mr B had a score of F, indicating independence in the continence field only, prior to IMT. The IMT was undertaken using a commercially available inspiratory threshold trainer, with an adjustable spring loaded valve. Due to the threshold nature of the device, the subject was required to generate a negative pressure greater than the indicated pressure for the valve to open. This ensured that the load applied to the inspiratory muscles is independent of flow and respiratory pattern. The IMT programme was given in addition to standard physiotherapy intervention patients received during their hospital admission. This standard care included respiratory care, assistance with mobilization and strengthening exercises. The IMT programme consisted of resisted breathing, where the added load was MIP load for eight breaths, three repetitions, twice daily. The treating physiotherapist supervised all treatment

sessions, which were completed daily without complication until hospital discharge. Mr A underwent four days of IMT and Mr B completed six days of IMT, where the load was increased by 5% of MIP to  $-29$  cm H<sub>2</sub>O on Day 6.

## RESULTS

Despite the brief duration of the training intervention, there were changes in the measures of MIP, MIP load, 6MWD and Katz ADL scores. MIP increased to  $-98.7$  cm H<sub>2</sub>O for Mr A, to 128% of predicted, or an increase of 17.8%. For Mr B there was a large increase in MIP to  $-53.5$  cm H<sub>2</sub>O, to 52% of predicted, or an increase of 234% since IMT. The endurance marker, MIP load, was also increased in both cases: Mr A and Mr C,  $-30$  cm H<sub>2</sub>O and  $-40$  cm H<sub>2</sub>O, which reflected 87.5% and 42.9% increases, respectively, compared with pre-IMT levels. These loads are greater than those achieved after up to four weeks IMT in slow-to-wean patients (Sprague and Hopkins, 2003). Improvements in exercise tolerance were also demonstrated after IMT, both cases increased the 6MWD to 257 m and 150 m, reflecting a 57.7% and more than 100% increase from pre-training measures (Mr A and Mr B, respectively). Improved performance on the Katz ADL scale was also demonstrated, with both patients being

independent in all functions assessed by the scale after training.

## DISCUSSION

The present Case Report describes the inclusion of IMT to the physiotherapy management and rehabilitation of two chronic critically ill patients who were discharged from intensive care.

One aspect of rehabilitation that was not being specifically addressed by present physiotherapy management is inspiratory muscle dysfunction after prolonged mechanical ventilation, despite the presence of inspiratory muscle weakness and reduced endurance following successful weaning from prolonged mechanical ventilation (Sprague and Hopkins, 2003; Chang et al., 2005). The present Case Report describes a novel method of IMT in the physiotherapy management of two chronic critically ill patients, which resulted in improvements in both inspiratory muscle strength and endurance markers. The IMT programme outlined in the Case Report was designed to provide an adequate training stimulus to induce neuromuscular changes, without the development of inspiratory muscle pump failure. This was achieved by providing rest periods during the training programme, and by monitoring the patient's perceived exertion, in a manner similar to previous studies in long-term intensive care patients (Martin et al., 2002; Sprague and Hopkins, 2003). The improvements in MIP and MIP load may reflect a training effect and were similar in magnitude to those found in studies of IMT in patients with chronic obstructive pulmonary disease (Preusser et al., 1994; Larson et al., 1999). The findings of this Case Report suggest that further controlled studies may be indicated to investigate the effect of IMT in chronic critically ill patients after intensive care discharge. As the duration of training was less than seven days, the training stimulus was probably insufficient to elicit significant muscular changes in fibre type or fibre cross-sectional area. Thus, changes in MIP and MIP load are likely to be a result of neural adaptation, such as improved ability to attain a maximal volitional contraction, decreased co-activation of antagonist muscle groups, enhanced motor unit synchrony or more efficient motor programming (Sale, 1988; Carolan and Cafarelli, 1992; Yue and Cole, 1992); however, the exact mechanism cannot be determined from these findings and requires further

study. Following IMT both patients demonstrated increased ADL performance and exercise tolerance, as measured by the 6MWD. Further controlled studies are needed to determine the extent to which this finding can be attributed to the effect of IMT, standard physiotherapy intervention or the natural course of recovery from a major illness. This is the first case report of IMT in the rehabilitation of chronic critically ill patients after ICU discharge. This study demonstrates that it is possible to include IMT in the physiotherapy rehabilitation of this clinical population, and its use may result in improvements in inspiratory muscle strength and endurance. The changes observed in the present Case Report, despite the short intervention period, were similar to those observed after IMT training in other clinical populations. Therefore, further controlled studies are needed to determine the effect of IMT in this population and to optimize the rehabilitation of chronic critically ill patients following ICU discharge.

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