The Metabolic Cost of Inspiratory Muscle Training in Mechanically Ventilated Patients

T. Jenkins[1], M. K. Poulsen[2], D. S. Karbing[2], S. E. Rees[2], D. Hall[3], B. V. Patel[4], M. I. Polkey[5], V. MacBean[6]; [1]Rehabilitation and Therapies Department, Royal Brompton and Harefield Clinical Group, Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom, [2]Respiratory and Critical Care Group, Department of Health Science and Technology, Aalborg University, Aalborg, Denmark, [3]Critical Care Department, Royal Brompton and Harefield Clinical Group, Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom, [4]Anaesthetics, Pain Medicine and Intensive Care, Imperial College London, London, United Kingdom, [5]Department of Respiratory Medicine, , Royal Brompton and Harefield Clinical Group, Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom, [6]College of Medicine, Health and Life Sciences, Department of Health Sciences, Brunel University London, London, United Kingdom.

Corresponding author's email: t.jenkins@rbht.nhs.uk

Rationale Diaphragmatic dysfunction is well documented following initiation of mechanical ventilation. Inspiratory muscle training (IMT) is used to facilitate weaning by strengthening the inspiratory muscles, yet the optimal approach remains uncertain. Whilst some data on metabolic response to whole body exercise in critical care exist, the metabolic response to IMT in critical care is yet to be investigated; such data could provide insight into the optimal IMT loading in critical care. Methods 26 co-operative, mechanically ventilated patients performed IMT using an inspiratory threshold loading device (Philips Respironics® Threshold IMT or PEP) set at 4cmH_2O, and at 30, 50 and 80% of their negative inspiratory force (NIF). Initially, baseline NIF was measured on the participant's ventilator. PaO_2/FiO_2, c-reactive protein (CRP) and vasopressor inotrope score were (VIS) measured before test start; oxygen consumption (VO_2) was measured continuously (Beacon, Mermaid care A/S, Noerresundby, Denmark). Baseline VO_2 was measured as a two-minute average during steady state of rest prior to IMT. Participants performed two sets of six breaths for each load with ventilatory pressure support set at 0 cmH_2O. Oxygen consumption was measured as a two-minute average immediately after the completion of IMT. To allow for recovery, patients rested for 10 minutes between each IMT load. VO_2 levels following each IMT dose were compared using one-way ANOVA with Fisher's LSD method for multiple post hoc comparisons. The dose-VO_2 response relationship, and the influence of baseline factors, was evaluated using linear mixed effects modelling (LMM). Results Baseline characteristics are presented in table 1.Mean(SD) VO_2 (ml/min) was 280(85) at baseline, significantly increasing to 327(87), 337(89), 350(101), 388(98) after IMT at 4cmH_2O and 30, 50 and 80% NIF respectively ($p<0.001$). Post hoc comparisons revealed significant differences in VO_2 between baseline and all IMT doses (4cmH_2O $p=0.015$, 30% NIF $p=0.004$, 50% NIF $p<0.001$ and 80% NIF $p<0.001$), and between 80% NIF and all other doses (4cmH_2O $p<0.001$, 30% NIF $p=0.002$ and 50% NIF $p=0.026$). LMM showed a dose-response slope of 5.3 ml/min/cmH_2O (95% confidence intervals 2.7-7.9, $p<0.001$). Baseline NIF had a significant effect on this relationship, with each 1cmH_2O increase in NIF decreasing the dose-response slope by -0.06 (-0.11 to -0.01) ml/min/cmH_2O. Conclusions IMT causes a statistically significant load dependent increase in VO_2 in critically ill mechanically ventilated patients. The dose response relationship of applied respiratory load and oxygen consumption is modulated by respiratory muscle strength; this may offer an approach to novel prescriptions of IMT.

Table 1 – Baseline characteristics	n=26 (median (IQR))
Sex, male: female	20:6
Age (years)	56.0 (43.0 – 65.3)
Estimated body weight (kg)	83.5 (67.5 – 100.5)
BMI (kg/m^2)	27.3 (23.1 – 33.4)
Length of mechanical ventilation prior to IMT (days)	18.0 (11.8 – 25.2)
Length of stay (ICU) prior to IMT (days)	21.0 (12.7 – 28.5)
APACHE 2 score (admission)	25.5 (19.7 – 32.2)
SOFA score	7.0 (6.8 – 10.0)
NIF (cmH_2O)	32 (22.6 – 39.3)
CRP	50 (20.5 – 75.5)
PaO_2/FiO_2	251.0 (219.0 – 318.0)
Pressure support (cmH_2O)	11.5 (9.5 – 15.0)
Vasopressor Inotrope Score	0.0 (0.0 – 4.0)

Abbreviations: APACHE II, Acute Physiology and Chronic Evaluation Score. SOFA, Sepsis Organ Failure Score.

This abstract is funded by: Royal Brompton and Harefield Hospital's Charity