Thoraco-pulmonary mechanical perturbations accompanying thoracic loading

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Mechanical perturbations to either the lung tissue or the chest wall can have deleterious effects upon thoraco-pulmonary mechanics, thereby modifying the work of breathing and possibly leading to respiratory-muscle fatigue. Thoracic loading, which is the most common form of ambulatory load carriage, is one example whereby an increase in the overall physiological strain is accompanied by modified, and sometimes impeded ventilation. However, the combined effects of the restrictive and inertial forces accompanying thoracic loading on the elastic properties of the entire respiratory system have not previously been evaluated. Therefore, we assessed the impact of thoracic loads on the static compliance of the lung tissue ($C_{st(l)}$), the chest wall ($C_{st(w)}$) and the total respiratory system ($C_{st(rs)}$), by varying both the size and distribution of loads around the chest wall.

Eleven males (age: 27.27 [SD 4.78] y, height: 182.12 [SD 6.74] m; mass: 79.55 [SD 8.42] kg) participated in four treatments on the same day: a control trial (clothing only), one load treatment with a 50: 50 mass distribution (anterior:posterior; 35 kg) and two loads with a 25: 75 mass distribution (35 and 54 kg). An oesophageal catheter and balloon (10 cm) was positioned behind the right atrium for the duration of the experiment, and used to estimate intrapleural pressure. For each condition, seated subjects performed static respiratory pressure-volume relaxation manoeuvres from residual volume to total lung capacity. Transpulmonary, transthoracic and transrespiratory static pressure-volume data were collected. Curve fitting permitted the *post hoc* attainment of tissue compliance for the lung tissue, chest wall and total respiratory system over resting tidal volumes (end-expiratory to end-inspiratory lung volumes).

Increasing thoracic loading significantly reduced lung-tissue, chest-wall and total respiratory compliance (Table; $P<0.05$). Varying the load distribution did not significantly influence either lung-tissue or chest-wall compliance ($P>0.05$). Nonetheless, load distribution did significantly alter the compliance of the total respiratory system, whereby the 25: 75 distribution (35 kg) significantly decreased compliance compared to the 50: 50 distribution of the same mass ($P<0.05$).

It was postulated that thoracic loading, which increases both the metabolic and ventilatory requirements of external work, would also modify the elastic properties of the respiratory system. The current observations demonstrate that the tissue compliance of the total respiratory system was firstly reduced in a mass-dependant manner, and further modified by distributing a greater proportion of a given mass onto the back. Such mechanical perturbations to the respiratory system are likely to elevate the elastic work of breathing, potentially predisposing to respiratory-muscle fatigue, under conditions in which thoracic load carriage elicits significant increases in ventilation.

Variable	**Control**	**50: 50 loading (35 kg)**	**25: 75 loading (35 kg)**	**25: 75 loading (54 kg)**
$C_{st(l)}$ ($L.kPa^{-1}$) n = 9	4.91 ±0.68	4.48 ±0.38	3.82 ±0.26	3.04 ±0.31*
$C_{st(w)}$ ($L.kPa^{-1}$) n = 7	4.50 ±0.49	3.72 ±0.69	3.14 ±0.30	2.81 ±0.46*
$C_{st(rs)}$ ($L.kPa^{-1}$) n= 11	2.64 ±0.26	1.92 ±0.10*	1.65 ±0.10*†	1.40 ±0.09*†‡

Values are means with standard errors of the means (±). Significant differences ($P<0.05$) are indicated by the symbols (* *versus* control, † *versus* **50**, 50 loading [35 kg], ‡ *versus* **25**, 75 loading [35 kg]).