Study proposal

Inspiratory and trunk muscle activity during inspiratory muscle training on stable and unstable surfaces in people after stroke

Objectives

This study aims to investigate the differences in muscle recruitment of the diaphragm (assessed using ultrasound), the sternocleidomastoid (SCM) and trunk muscles (both measured via surface electromyography (sEMG)), during loaded breathing training performed on both stable and unstable surfaces. The goal is to understand the interaction between the inspiratory and trunk muscles during inspiratory muscle training (IMT) across these two surface conditions.

Materials and methods

This cross-sectional observational study has been approved by the Institutional Review Board of Hong Kong Metropolitan University (Ethics approval number: HE-OT2023/13) and Shenzhen Second People's Hospital (Ethics approval number: 2023-274-01PJ).

Participants

Sample size calculation

The sample size was calculated using G*Power 3.1.9.7. Repeated-measures analysis of variance (ANOVA) will be the primary statistical method for comparing changes in diaphragmatic thickness between different loaded inspiratory training protocols. Based on an estimated effect size of 0.25, an alpha level of 0.05, and a power of 0.80, the required sample size is 24.

Inclusion criteria

(1) Age ⩾ 40 years and < 80 years; (2) breathing spontaneously; (3) clinically diagnosed with ischemic and/or hemorrhagic stroke; (4) duration of stroke from onset falls within 1 month to 12 months after diagnosis; (5) no thoracic or abdominal surgery within the last 6 months; (6)

no cognitive impairment (Montreal Cognitive Assessment (MoCA) score ⩾ 26); (7) able to understand and follow verbal instructions; (8) no facial palsy, or mild facial palsy without limitation of labial occlusion; (9) able to complete all loaded breath tests on stable and unstable included in this study.

Exclusion criteria

(1) Acute myocardial infarction or acute heart failure; (2) acute pain in any part of the body; (3) the history of chronic respiratory illness or positive clinical signs of impaired respiratory function (such as shortness of breath, hypoxemia, chronic cough, and sputum retention); (4) patients with a nasal feeding tube, tracheal tube, or any condition that prevents the measurement or implementation of the study procedures.

Procedures

Participants will be instructed to perform 10 loaded breaths via a threshold inspiratory load device (POWERbreathe KH2, UK) on both a stable surface (sitting on a chair, Protocol 1) and an unstable surface (sitting on a soft pad, Protocol 2) in random order. The inspiratory load/resistance will be set at 50% of the MIP, an intensity previously shown to elicit maximal diaphragm contraction. During all breathing protocols, participants' feet will be supported on the ground, and a nose clip will be employed to prevent air leakage. Bilateral muscle activity of the diaphragm (measured by ultrasonography), as well as the SCM and trunk muscles—including the rectus abdominis (RA), external oblique (EO), internal oblique/transversus abdominis (IO/TrA), and erector spinae (ES)—will be simultaneously recorded using sEMG during all breathing protocol tests. Self-perceived exertion levels after each loaded breath protocol will also be recorded using the modified Borg Rating Scale of Perceived Exertion.

Outcome Measurements

Diaphragm contraction

The magnitude of diaphragmatic contraction will be reflected by the diaphragm thickening fraction (DTf). The DTf will be calculated by the difference between the mean diaphragmatic thickness at the end of each loaded breathing protocol and the mean diaphragmatic thickness at the end of tidal expiration, then divided by the diaphragmatic thickness at the end of tidal expiration.

Two identical ultrasound machines (Mindray M9, Shenzhen, China) will be used for measurement of diaphragmatic thickness of both hemi-diaphragms. Tidal inspiration and expiration diaphragmatic thickness will be measured before the loaded inspiratory protocol, and three images will be captured for each phase and averaged for subsequent data analysis. The diaphragm thickness at the end of each loaded breath (from a total of 10 breaths) will be recorded, and the average will be calculated to determine the DTf for each loaded inspiratory protocol.

Recruitment of SCM muscles and trunk muscles

A Noraxon Ultium wireless surface EMG system (Noraxon USA, Inc., Scottsdale, AZ, USA) will be used to measure bilateral muscle activity in SCM and trunk muscles simultaneously during all breathing protocol tests.

Self-perceived exertion level

Self-perceived exertion level at the end of each 10-breath set at each protocol, will be also recorded using the Borg's scale of Rate of Perceived Exertion.

Statistical analysis

All data were analyzed using the IBM SPSS Statistics for Windows, Version 25.0 (Armonk, NY: IBM Corp).

Changes in DTf, SCM muscle activity, and trunk muscle activity will be analyzed using repeated-measures ANOVA, comparing the hemiplegic and non-affected sides within each protocol, and between the different inspiratory protocols.

Perceived exertion levels will be compared between the two protocols using the Wilcoxon signed-rank test.