

Cardiac Coupling Response to Chest Wall Strapping in Chronic Obstructive Pulmonary Disease Patients

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Introduction

- Chronic obstructive pulmonary disease (COPD) – characterized by limited expiratory airflow due to lung destruction and/or airway obstruction (Hogg et al., 2004)
 - Higher risk of cardiovascular morbidity (De Blois et al., 2010) – effects are better understood than causes/mechanisms
- Cardiorespiratory coupling (= cardiorespiratory reflex)**
 - Diaphragm moves down and decreases pressure in chest during inhalation → blood pulled out of extremities
 - Lung stretch receptors are activated → reflex accommodates for increased blood return by increasing heart rate
- COPD patients have reduced autonomic nervous system activity (van Gestel et al., 2010) → may also have reduced cardiac and respiratory reflexes
- Chest wall strapping (CWS)** - technique used to induce breathing at low lung-volumes
 - CWS has been shown to increase expiratory flow rates and detectable small airways using CTs (Eberlein et al., 2014; Taher et al., 2018)

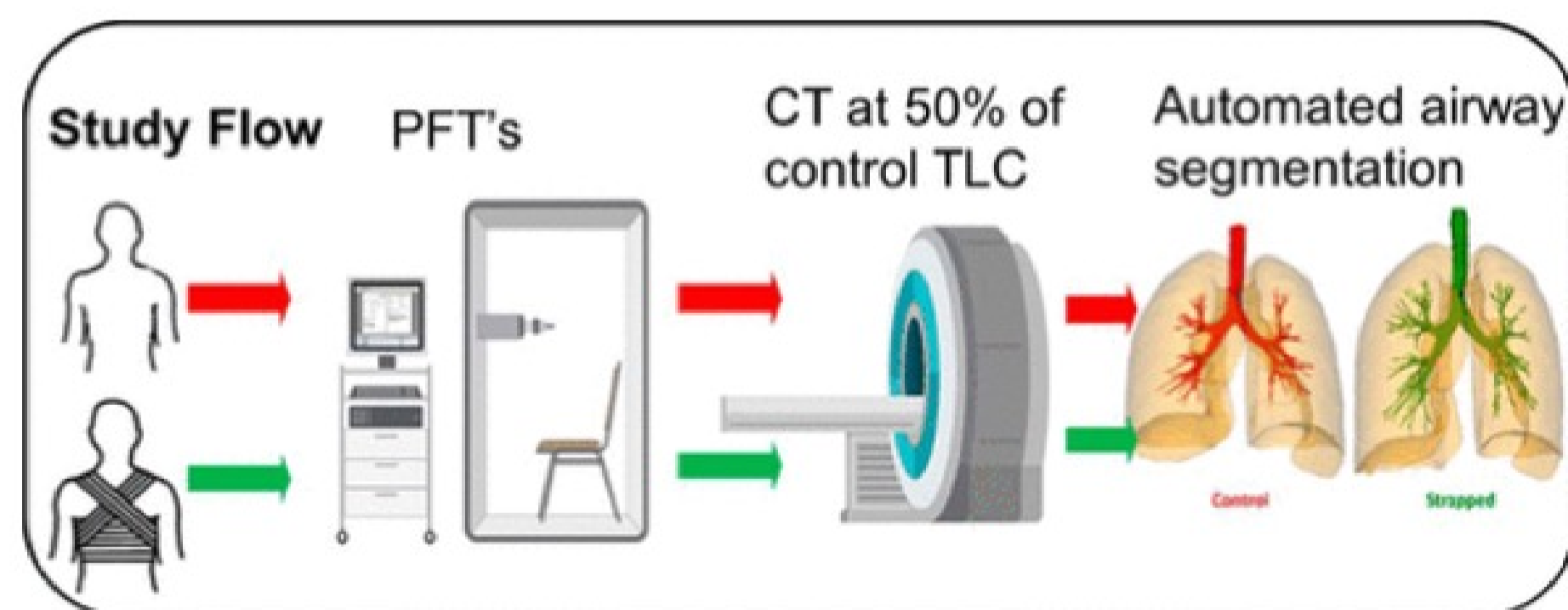


Figure 1: Study flow for a CWS experiment done by Taher et al., which revealed that CWS increased the number of small airways found using CT. On the bottom left of the figure is a diagram of a chest wall strapping device. Image credit: Taher et al., 2018.

Hypothesis

- COPD patients have a diminished cardiorespiratory coupling response compared to patients with normal respiratory function
- When subjected to chest wall strapping, both COPD and control patients have an increased cardiorespiratory coupling response

Methods

- 6 male control participants, absence of cardiopulmonary disease
- 5 male COPD participants; mild – moderate COPD (GOLD)
- Collection of breathing data followed procedures outlined in Seymour et al., 2019



Baseline: 32 breaths
CWS and Post-CWS: 16 breaths every 15 mins.

- Plethysmography, spirometry, and volumetric capnography to collect ventilation data (e.g., tidal volume and CO₂%) (Seymour et al., 2019)
- Piezo-electric transducer on the index finger to measure heart rate

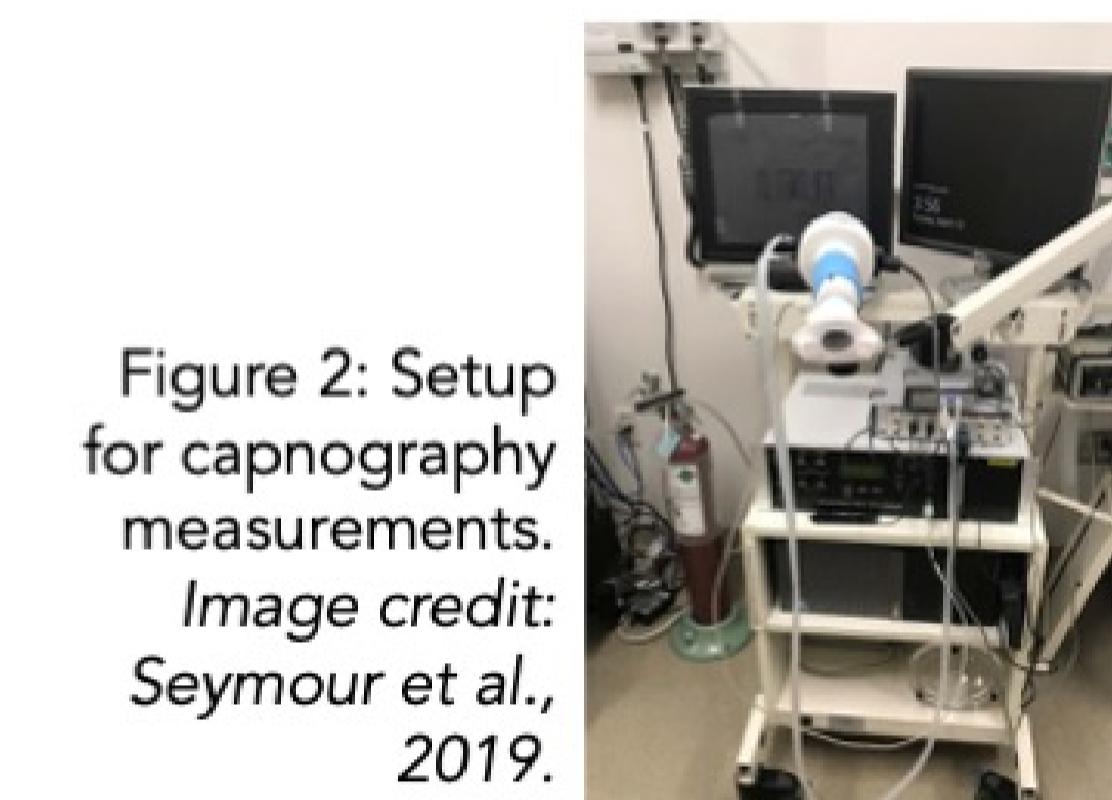


Figure 2: Setup for capnography measurements. Image credit: Seymour et al., 2019.

Results

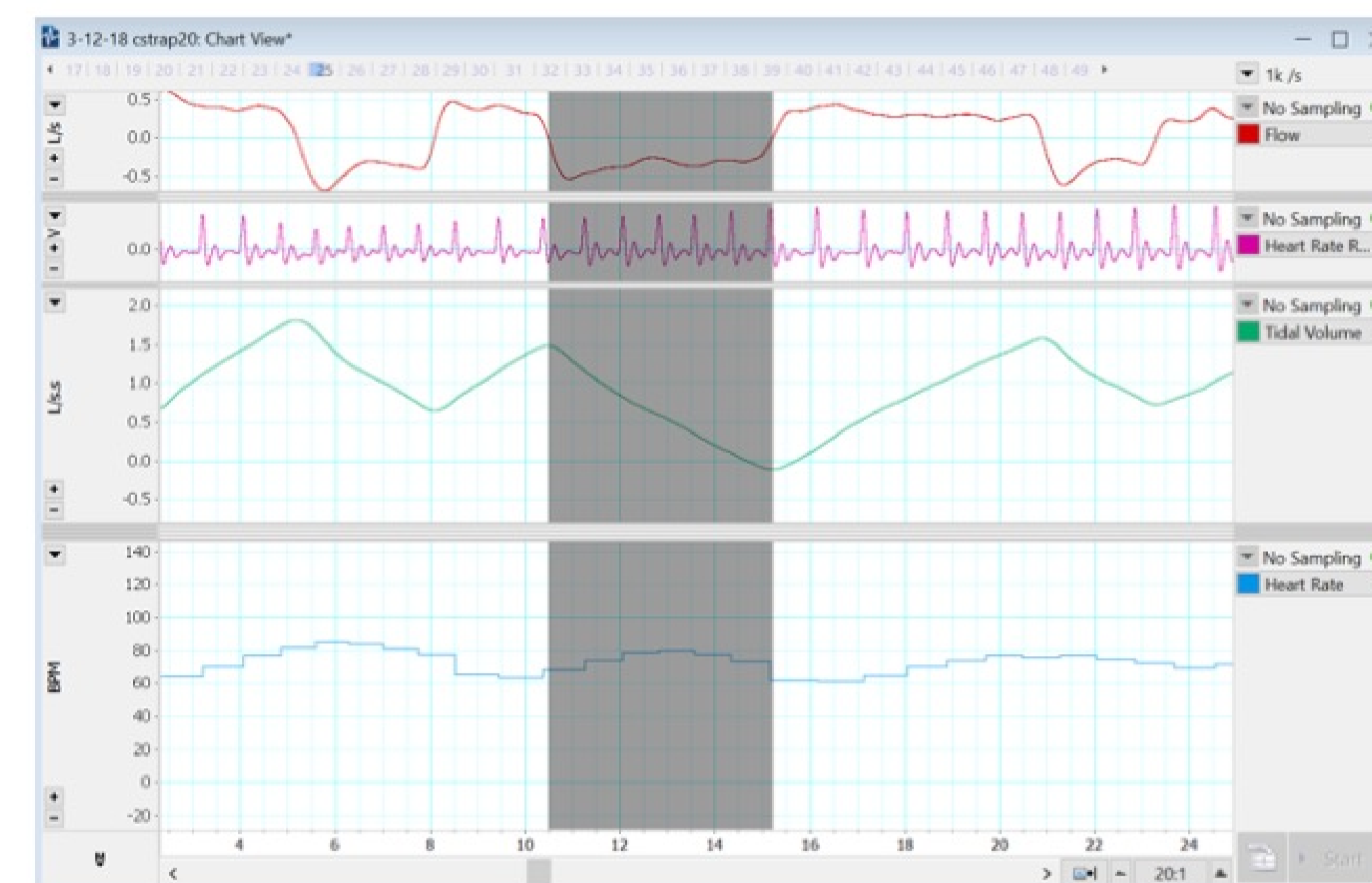


Figure 3: Example selection of an inhalation breath in LabChart software. The red line represents the patient's flow rate (L/s), pink represents raw heart rate (V), green represents tidal volume (L), and blue represents heart rate (bpm).

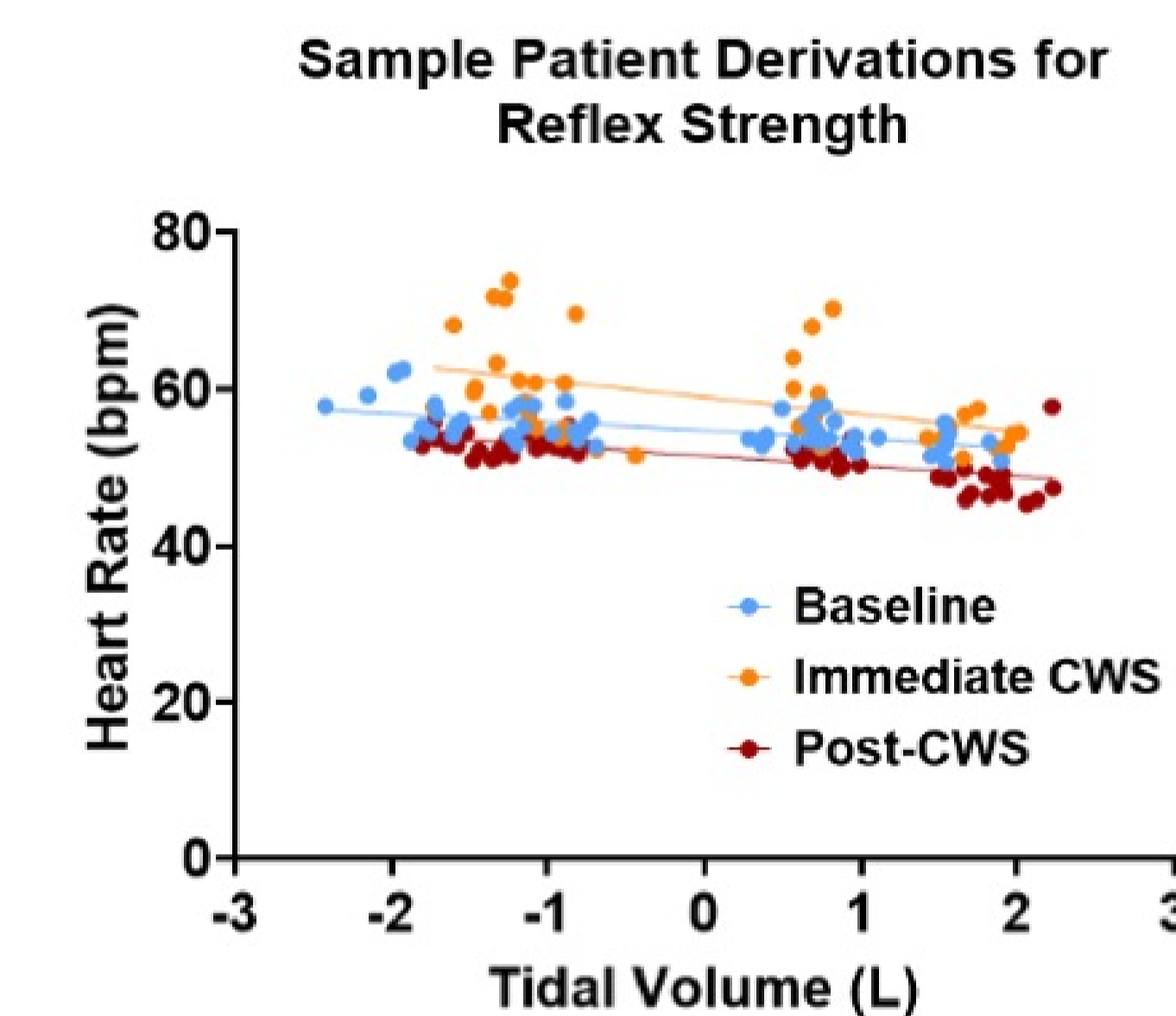


Figure 4: Linear regressions for Heart Rate vs. Tidal Volume plot of example patient data. Each point represents the average heart rate during an inhalation (negative tidal volume) or exhalation (positive tidal volume). The slopes of each linear regression represents the strength of the reflex (bpm/L).

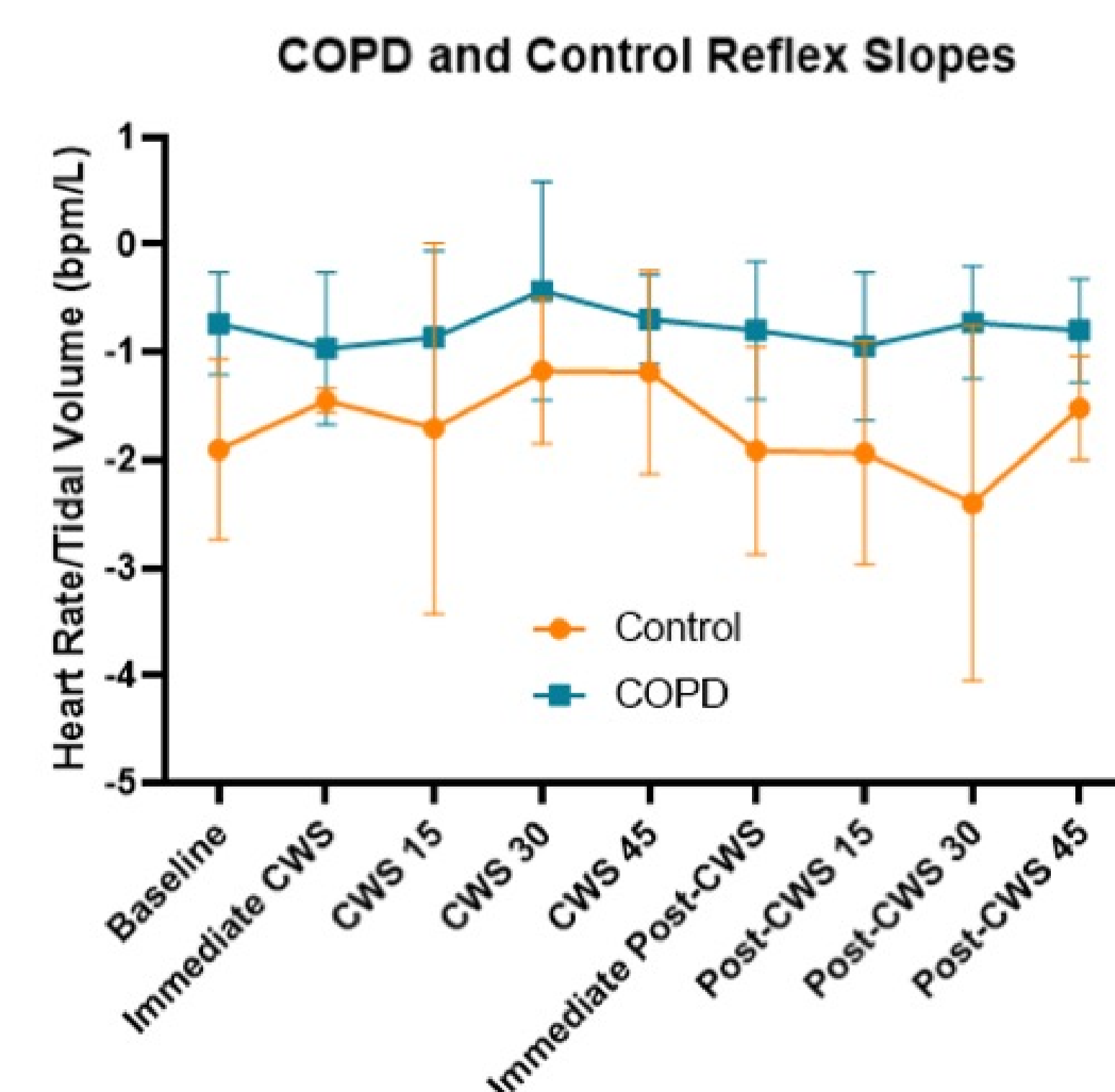


Figure 5: Average strength of the reflex in COPD and control patients during baseline, CWS, and post-CWS measurements. Multi-factor ANOVA statistics revealed a significant result comparing control vs. COPD ($p < 0.001$) and patient ($p = 0.003$). CWS condition was not significant ($p = 0.116$).

Implications/Conclusions

- COPD patients exhibit weaker cardiorespiratory reflexes compared to controls ($p < 0.001$)
 - Neural pathways/receptors may be damaged from COPD or noxious gases/particles
- COPD patients in this study were not severely sick but still had a blunted reflex
 - If heart rate does not increase during inhalation to compensate for increased venous return, then heart must generate bigger stroke volumes
 - Continuous strain on heart walls could result in weakening of the right side of the heart, which is more vulnerable to damage than the left
- CWS does not significantly affect the strength of the reflex in COPD or control patients ($p = 0.116$)
 - Same-sized breath will make heart respond similarly regardless of the total lung capacity
 - Unclear which aspect of the physiological response to CWS impacts cardiorespiratory coupling
- Future Directions
 - Test activity of other segments of reflex pathway in COPD patients
 - Measure breathing over longer periods of time

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