

# Heart Rate Response to End-Expiratory Apnea During Hypercapnia

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## RATIONALE

- Previous investigations have demonstrated a greater bradycardic response to apnea after exposure to acute and chronic hypoxia (versus normoxic responses). (1, 2)
- Hypoxia and hypercapnia elicit similar sympathetic, cardiovascular, and ventilatory responses during free breathing. (3)

### We sought to investigate if:

- Hypercapnia elicits a similarly enhanced bradycardic response as hypoxia during apnea.

**We hypothesized that apneas after breathing hypercapnia would cause an augmented bradycardic response compared to apneas conducted during normocapnia.**

## METHODS

- Heart rate (3-lead ECG), blood pressure, end tidal partial pressures of O<sub>2</sub> & CO<sub>2</sub>, ventilation, and oxygen saturation were measured continuously.
- There were no differences in responses to apnea in males and females; therefore, data for males and females are pooled.

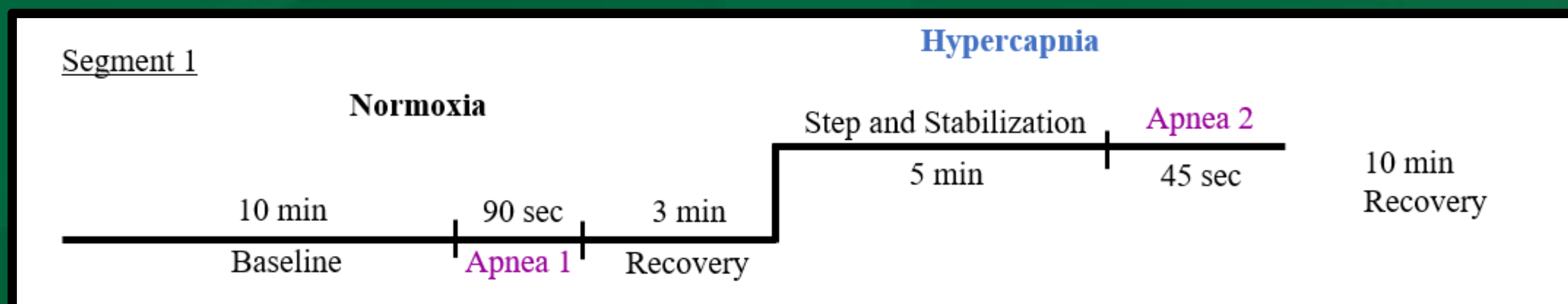


Figure 1. Experimental protocol. Apnea durations are approximate and participants were asked to hold their breath until volitional failure. Note: participants completed two additional conditions (hypoxia and hypercapnic hypoxia) as part of a larger project; only data from the hypercapnic condition are presented on this poster.

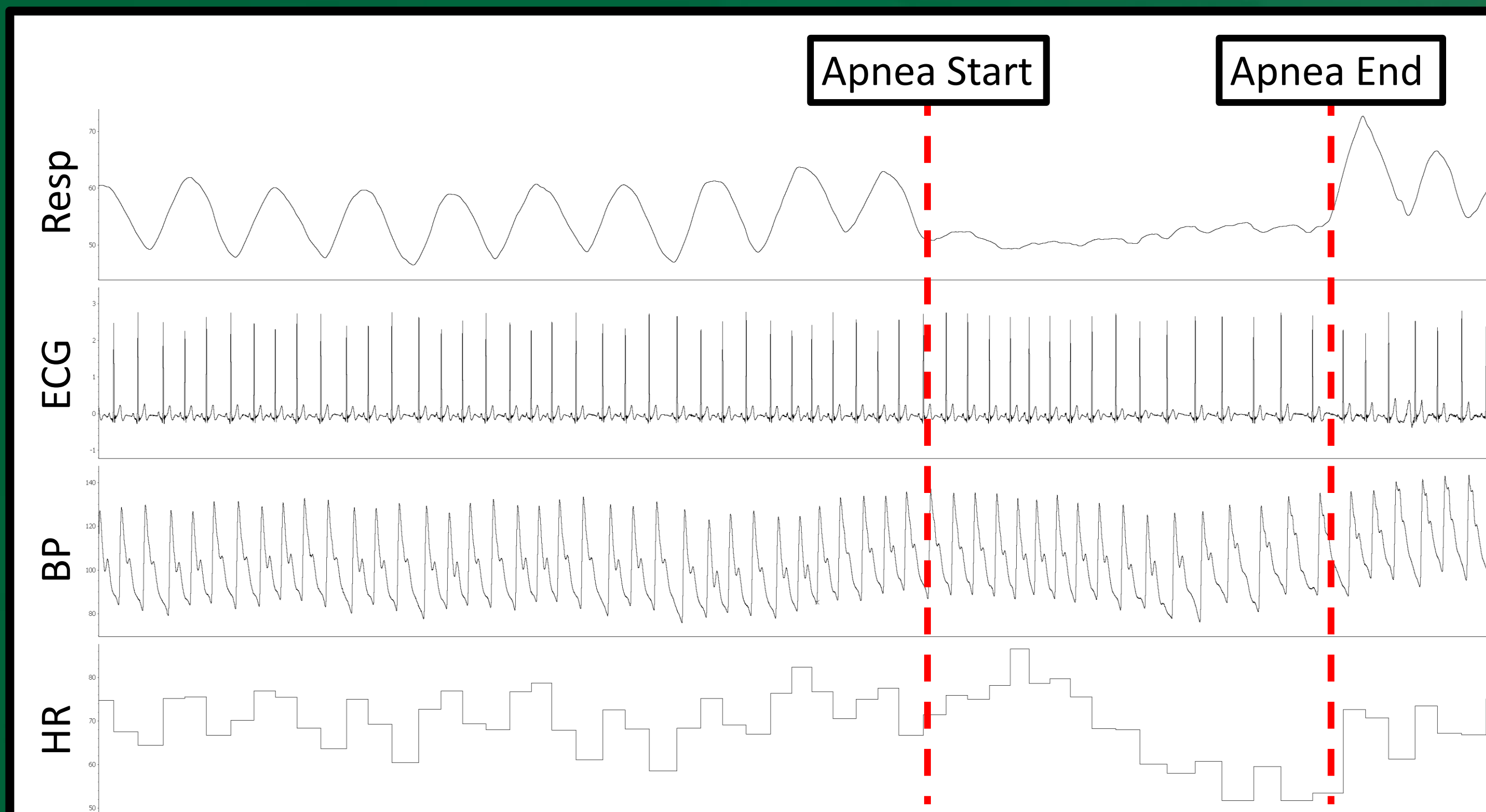


Figure 2. Representative tracing of respiration (Resp), ECG signal, blood pressure (BP) and heart rate (HR) during a hypercapnic apnea.

Table 1. Participant demographics.

	Males (n = 13)	Females (n = 12)
Age (years)	23 ± 2	23 ± 3
Height (cm)	178 ± 8	165 ± 5*
Weight (kg)	76 ± 14	65 ± 11*
BMI (kg/m <sup>2</sup> )	24 ± 3	24 ± 4

Data are presented as mean ± SD. \* P < 0.05 vs. males.

## RESULTS

Table 2. Baseline values for the minute prior to each apnea (n = 25).

	Normocapnia	Hypercapnia	P
HR (bpm)	70 ± 9	73 ± 10	<b>0.006</b>
MAP (mmHg)	88 ± 5	92 ± 6	<b>&lt;0.001</b>
SBP (mmHg)	115 ± 7	121 ± 10	<b>&lt;0.001</b>
DBP (mmHg)	74 ± 6	77 ± 6	<b>&lt;0.001</b>
P <sub>ET</sub> CO <sub>2</sub> (torr)	40 ± 3	46 ± 4	<b>&lt;0.001</b>
P <sub>ET</sub> O <sub>2</sub> (torr)	91 ± 5	90 ± 5	<b>0.004</b>
SpO <sub>2</sub> (%)	98 ± 1	98 ± 1	<b>0.027</b>
VE (L/min)	13 ± 4	22 ± 7	<b>&lt;0.001</b>

Data are presented as mean ± SD. HR heart rate, MAP mean arterial pressure, SBP systolic blood pressure, DBP diastolic blood pressure, P<sub>ET</sub>CO<sub>2</sub> end-tidal carbon dioxide, P<sub>ET</sub>O<sub>2</sub> end-tidal oxygen, SpO<sub>2</sub> arterial oxygen saturation, VE minute ventilation. Statistical significance is set at P < 0.05 (bolded).

Table 3. Apnea duration and cardiovascular values during apneas (n = 25).

	Normocapnia	Hypercapnia	P
Apnea Duration (s)	23 ± 8	19 ± 7	<b>&lt;0.001</b>
ΔHR (bpm)	-11 ± 15	-14 ± 14	0.069
ΔMAP (mmHg)	23 ± 10	21 ± 8	0.395

Data are presented as mean ± SD. ΔHR change in heart rate from baseline to nadir during apnea, ΔMAP change in mean arterial pressure from baseline to peak during apnea. Statistical significance is set at P < 0.05 (bolded).

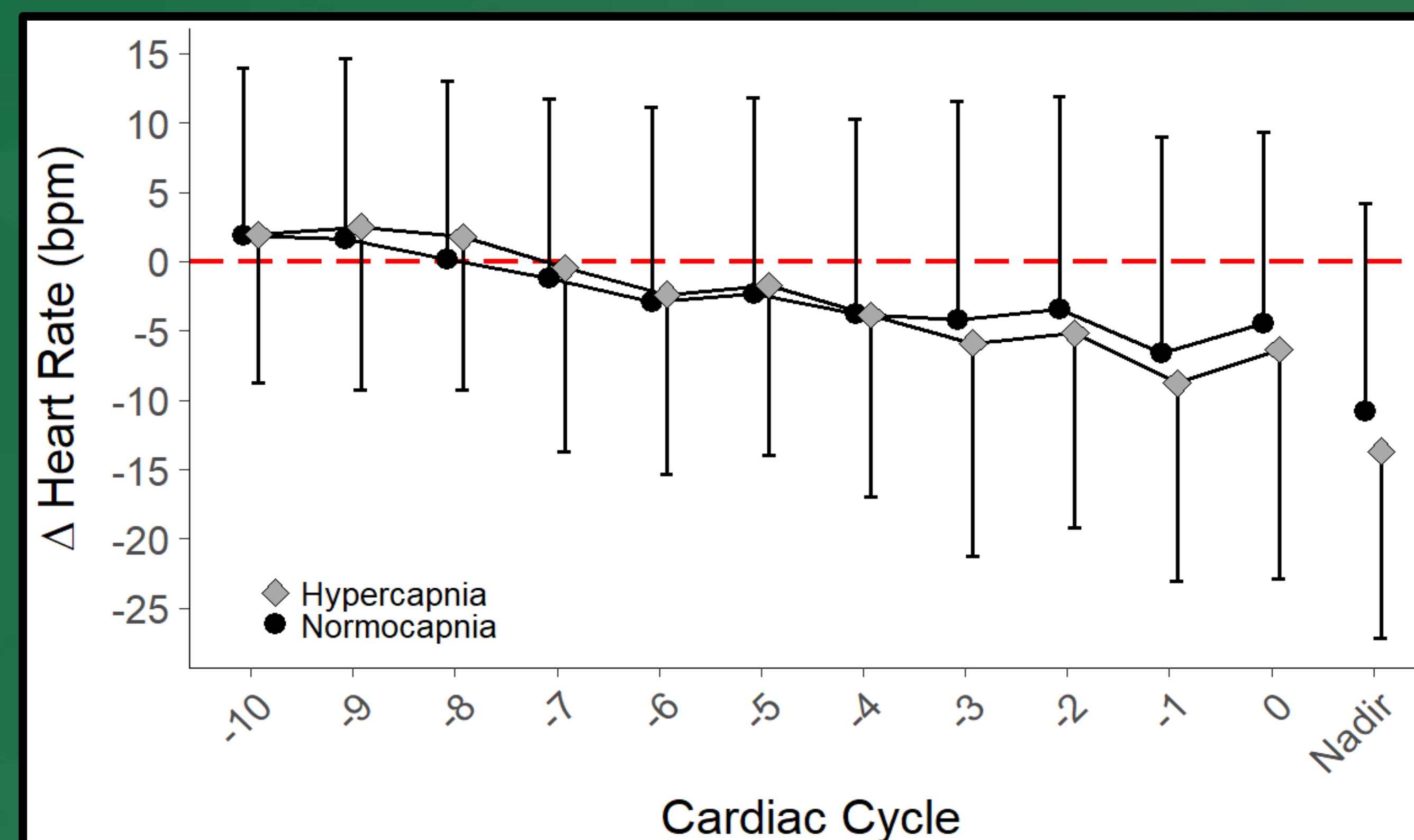


Figure 3. Mean (± SD) change in heart rate during the final 10 cardiac cycles of apnea after hypercapnia (diamonds) and normocapnia (circles) relative to the resting heart rate averaged from 1 minute preceding each respective apnea (n = 25). The nadir is the mean response of each participant's single lowest beat during the final 10 cardiac cycles of each apnea. No statistically significant differences between conditions during any beat.

## FUNDING

This study was funded by an NSERC Discovery grant (CDS).

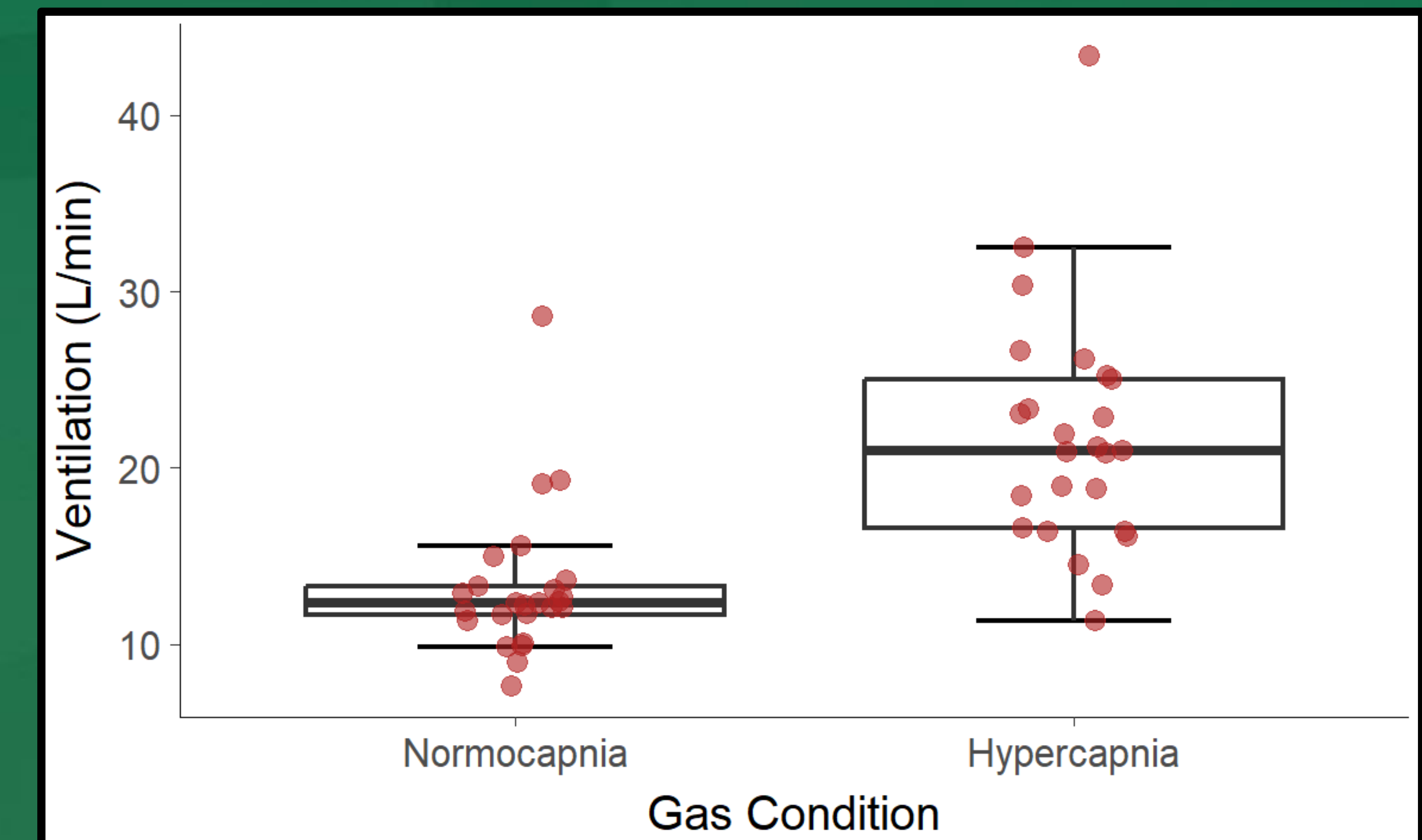


Figure 4. Ventilatory response to normocapnia and hypercapnia (n = 25). Hypercapnia elicited a greater ventilatory response (P < 0.001) than normocapnia.

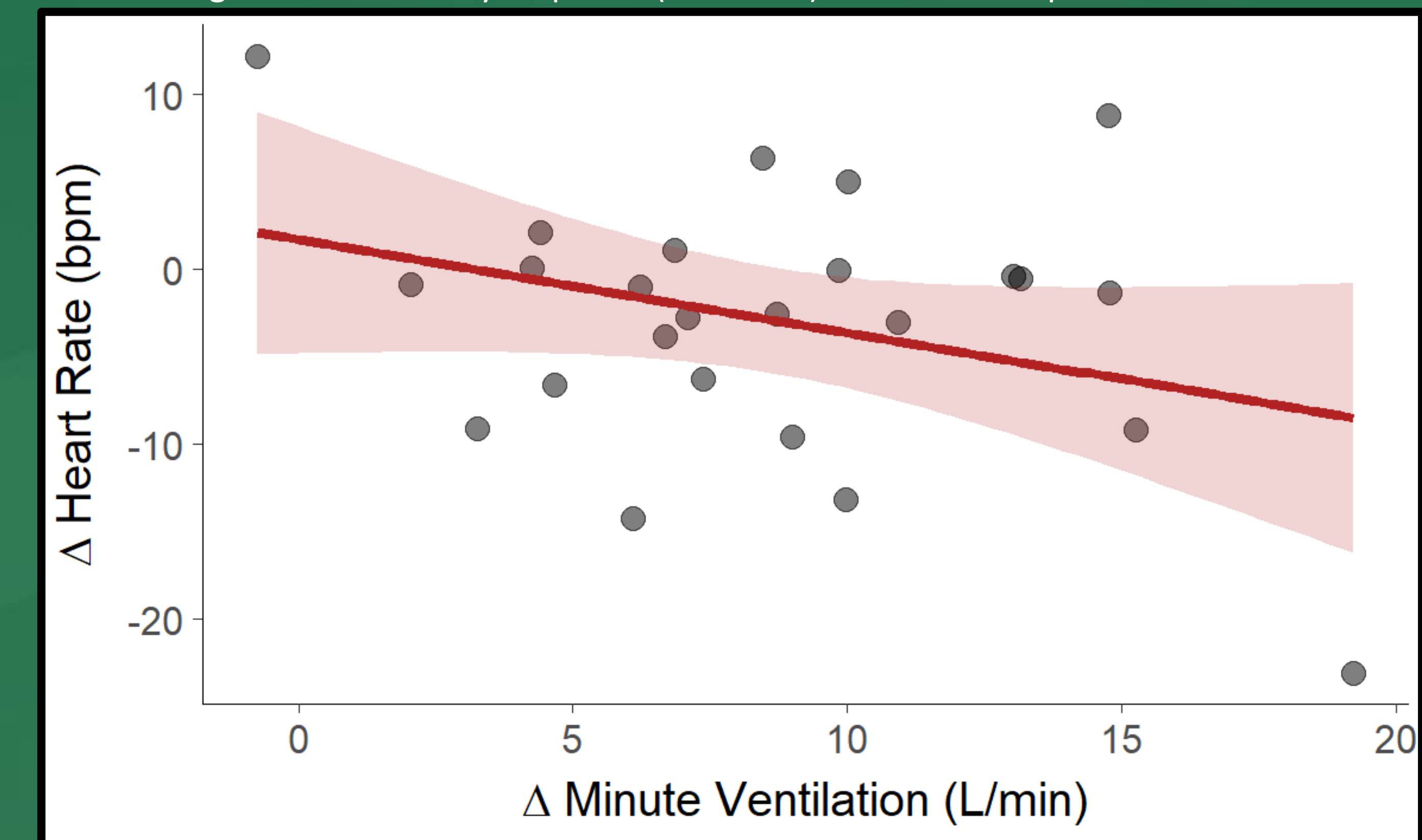


Figure 5. Relationship between the ventilatory response to hypercapnia and the subsequent heart rate response to apnea. Linear regression model suggests there is no relationship (r = -0.324, P = 0.114, n = 25). The y-axis depicts the difference in the change in heart rate from baseline to nadir between hypercapnia and normocapnia (note: a negative value indicates a greater bradycardic response during hypercapnia). The x-axis depicts the difference in ventilation between hypercapnia and normocapnia (note: a positive value indicates a greater ventilatory response during hypercapnia). Shaded area represents the 95% CI of the regression curve.

## INTERPRETATIONS

- Our data demonstrate that hypercapnia does not augment the bradycardic response to apnea; this response differs from that seen during hypoxia. (1)
- An absence of statistically significant bradycardia suggests that cardiovagal output is not increased during hypercapnia.
- No individual predictions can be made about the heart rate response to apnea based on the preceding ventilatory response to hypercapnia.

## REFERENCES

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