

# PULMONARY FUNCTION RESPONSE TO RECREATIONAL-TECHNICAL CLOSED-CIRCUIT REBREATHER TRIMIX DIVING



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## Introduction

- Extreme diving exposures, typically professional, have been associated with transient changes in standard measures of pulmonary function.<sup>2,3,4</sup>
  - in contrast, single, shallow, short duration recreational dives reportedly produce little change.<sup>1,5,6</sup>
- Recreational-technical divers now commonly complete dives far in excess of traditional recreational limits, both in depth and duration.
  - the acute response to these extended range exposures, particularly with closed-circuit rebreathers (CCR), have not been fully investigated.
- We sought to evaluate pulmonary function changes following recreational-technical CCR dives beyond 60 msw (200 fsw) in depth.

## Methods

- Pulmonary function was assessed in 18 volunteers (11 male, 7 female) before and shortly after open water CCR dives of their choice (Table 1).
  - trimix gas mixtures were appropriate for dive depth.
    - range: 9-10% oxygen, 50-60% helium, balance nitrogen.

Table 1: Subject anthropometrics

	Overall		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
Age (y)	51	6	52	7	50	3
Weight (kg)	83	17	92	13	68	10
BMI (kg·m <sup>-2</sup> )	26.6	3.1	27.5	2.8	25.1	3.2

- Standard spirometric measures (MIR Spirobank II™) included:
  - forced vital capacity (FVC) (Figure 1).
  - forced expiratory volume in one second (FEV<sub>1</sub>).
  - forced expiratory flow 25-75% (FEF<sub>25-75</sub>).
- Data are presented as mean±SD with ranges, as appropriate (Table 2).
  - predicted values (percent of pre-dive), pre-dive, and post-dive.
- Differences between pre-dive and post-dive measures were assessed with Student's t tests.
  - significance accepted at p<0.05.



Figure 1: Subject performing forced vital capacity test

## Results

- Spirometric measures were captured before and after 42 open water dives:
  - 76±13 (60-96) msw (248±42 [196-315] fsw).
  - 130±41 (55-260) min total run time.
  - 28±4 (11-31)°C (81±7 [52-87]°F) water temperature.
  - 4<sup>th</sup>±2<sup>nd</sup> (2-8) dive of the current series.
- Pulmonary function tests were performed at 66±23 (24-103) min pre-dive and 18±9 (2-58) min post-dive (Figure 2).
  - longest single case delays in post-dive testing were 30 and 58 min.

Table 2: Standard spirometry measures with pre-/post-dive comparison statistics

	Predicted (% of pre-)	Pre-dive (L)	Post-dive (L)	Pre-/Post-p value
FVC	111±18	4.79±1.02	4.80±1.08	0.816
FEV <sub>1</sub>	104±20	3.68±0.90	3.66±0.93	0.716
FEF <sub>25-75</sub>	90±33	3.37±1.37	3.33±1.32	0.601
FEV <sub>1</sub> /FVC	95±9	0.77±0.07	0.76±0.08	0.485

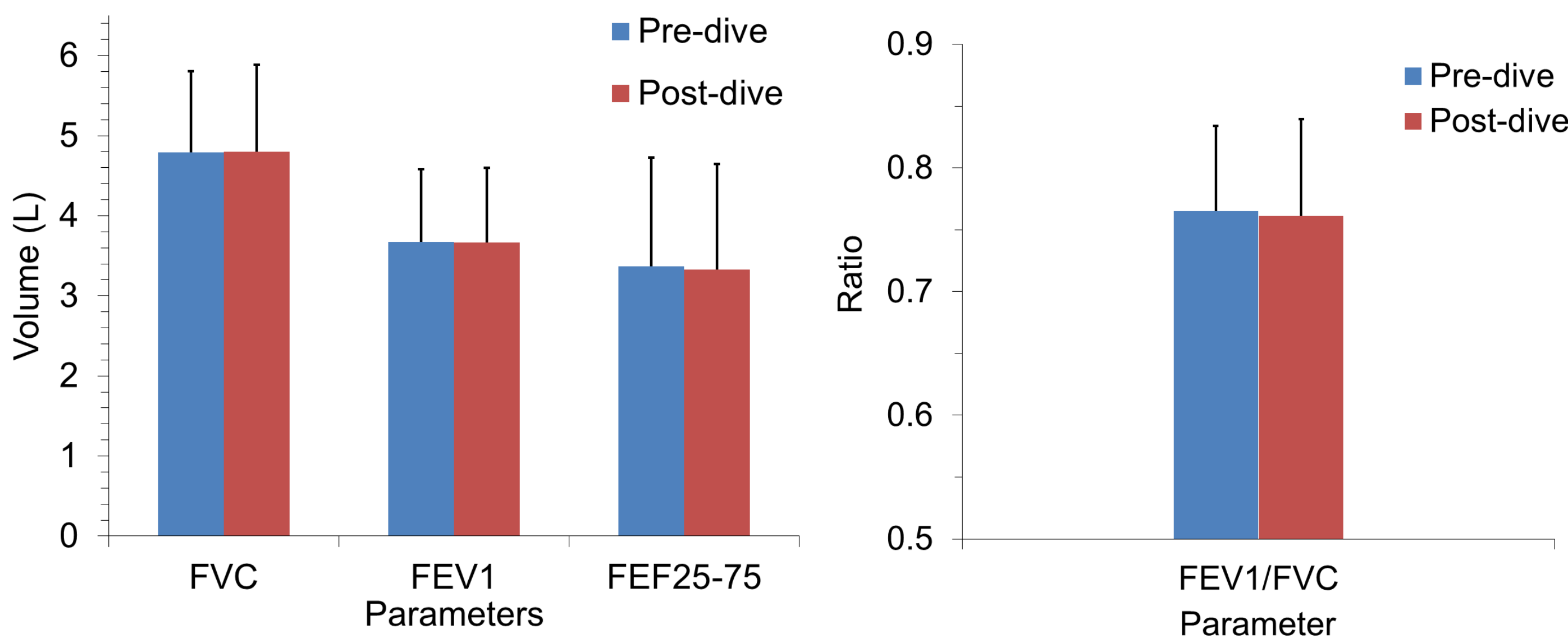


Figure 2: Comparison of pre- and post-dive spirometry values

## Discussion

- Recreational dives have been reported to produce little change in pulmonary function.<sup>1,5,6</sup>
- Pulmonary function compromise has been reported following professional diving exposures.
  - decrements in FVC<sup>3</sup>, FEV<sub>1</sub><sup>2,3,4</sup>, and FEF<sub>25-75</sub><sup>2</sup>.
- Recreational-technical CCR divers now conduct long dives that may include phases of substantial elevation in respiratory loading.
  - due to increased breathing gas density, equipment, and body position factors.
- The threshold at which significant changes in pulmonary function occur may be found in the recreational-technical CCR diving range.

## Conclusions

- We did not find significant differences pre- and post-dive in standard measures of pulmonary function with recreational-technical CCR dives in series conducted primarily in tropical water.

## Limitations

- Motion effects may have affected shipboard measures in some cases.
- Diver-subjects were conducting a series of daily dives. While each captured dive was the first of the day, the captured days in the series varied.
- As part of an observational study, divers controlled their own dive profiles and PO<sub>2</sub> setpoints.
- Pre-dive measures had to be taken in advance of final preparation to dive to avoid pre-dive distraction. Post-dive measures were taken as soon as practicable, but not immediately in all cases.
- Additional measures, for example, maximal voluntary ventilation, could be useful to assess impact, but divers were resistant to these measures both pre- and post-dive.

## Future Work

- Studies of expanded range of recreational-technical diving to determine thresholds to induce changes.
  - longer repetitive series, capturing dives on a consistent schedule.
  - deeper depths and longer run times.

## References

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