



The effect of PO_2 on ventilation, blood gases, and pulmonary hemodynamics during prolonged cold water immersed prone exercise at 122 fsw

Fraser JA, Peacher DF, Freiburger JJ, Natoli MJ, Schinazi EA, Beck IV, Walker JR, Doar PO, Boso AE, Walker AJ, Kernagis DN, Moon RE

Center for Hyperbaric Medicine and Environmental Physiology
Duke University Medical Center • Durham, North Carolina

USN Phase 7: Causes and Prevention of Immersion Pulmonary Edema



Background: Immersion Pulmonary Edema (IPE)

- First Described by Wilmshurst *et al.* in 1989
 - Cough, dyspnea, hemoptysis and hypoxemia after surface swimming or diving
 - Accumulation of fluid in lungs
 - Often in young, healthy individuals
- Unclear pathogenesis but known risk factors
 - Increased pulmonary vascular pressures
 - Heavy exertion
 - Cold water
 - Negative static lung load
 - Fluid loading
 - Polymorphism in the β_2 adrenergic receptor, eNOS, ACE?

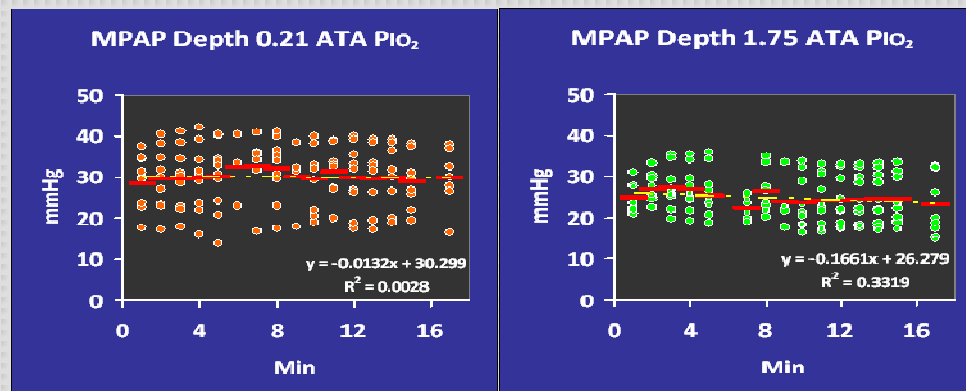


Conclusions from previous phases

- Immersion causes a rise in intravascular pressures, accentuated by exercise and cold water
 - Regulated mostly by torso rather than head or face temperature
- Individual variability in response of pulmonary pressures to cold water immersion
 - Study of one individual who experienced IPE revealed PAP/PAWP values at the upper end of normal, consistent with high PA pressures as cause for IPE
- High PO_2 attenuates the increase in PAP during exercise in thermoneutral water

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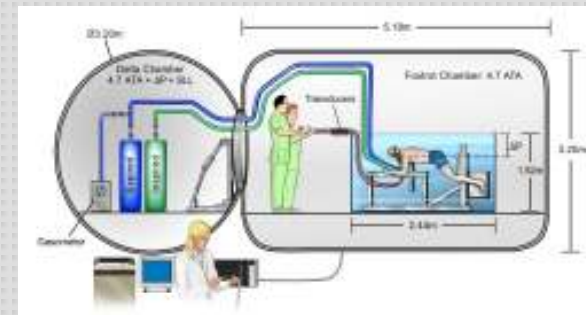


Hypothesis

- Breathing an enriched oxygen mixture will reduce pulmonary vascular pressures during exercise in cold water

Methods

- Institutional approval and informed consent obtained
- Subjects
 - 6 males aged 23-35
 - Baseline $\text{VO}_{2\text{max}}$ between 32.5 and $60.8 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$
 - Arterial and PA catheters
 - PO_2 0.21 and 1.75 ata in random order
 - Average pool temp 20.3°C
 - Work rate 150-175W
- Measurements
 - Obtained in early (6 min) and late (15 min) exercise
 - MAP, CVP, MPAP, PAWP, cardiac output (Fick), V_E , VO_2 , VCO_2 , arterial and mixed venous blood gases
- Data analysis
 - Mixed model using JMP (SAS, Cary NC)



Pressurize
to 122 fsw

Exercise 15 min at PO_2 1.75 ata/0.21 ata

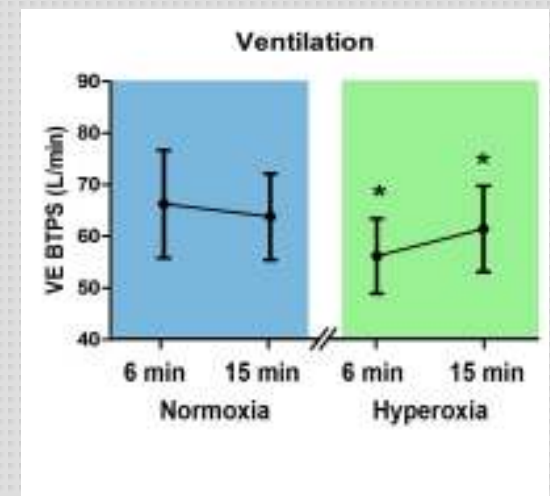
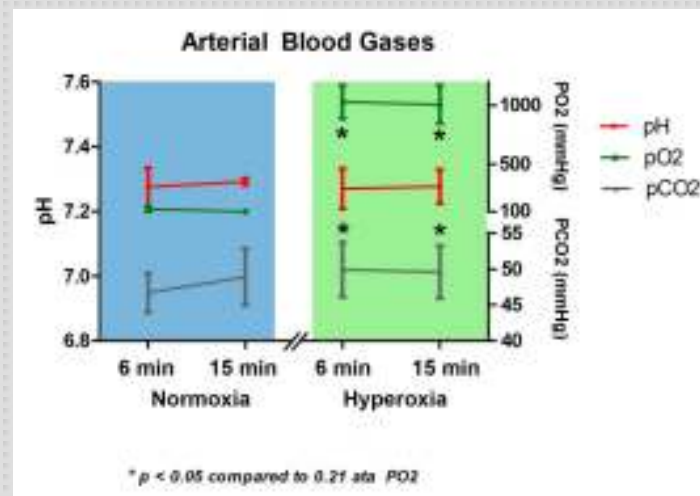
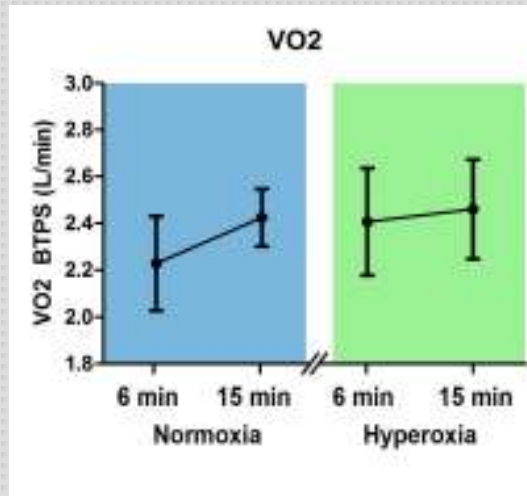
5 minute rest

Exercise 15 min at PO_2 0.21 ata/1.75 ata

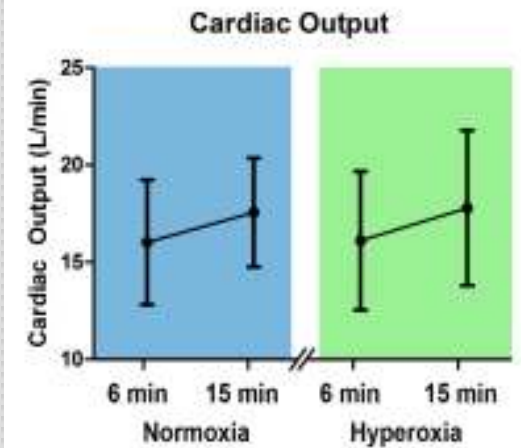
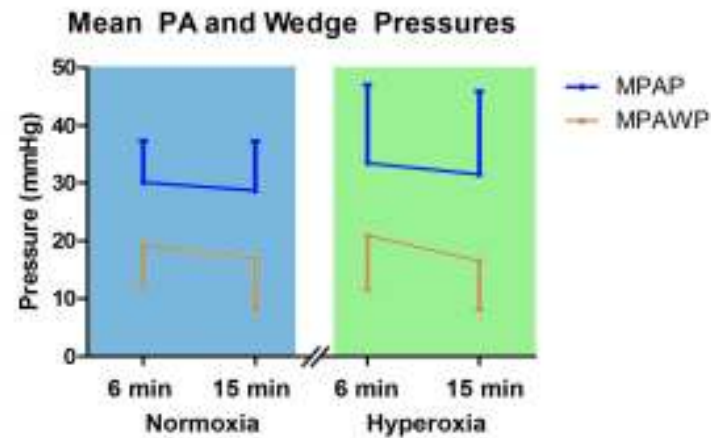
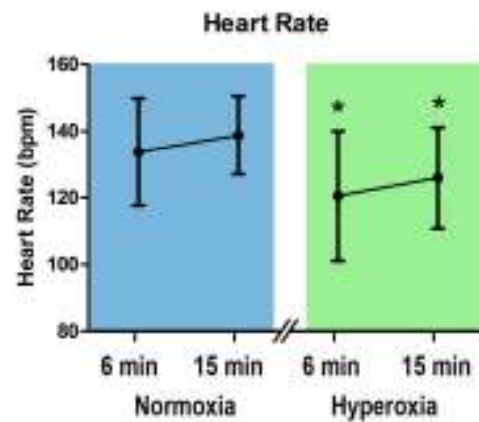
Decompression



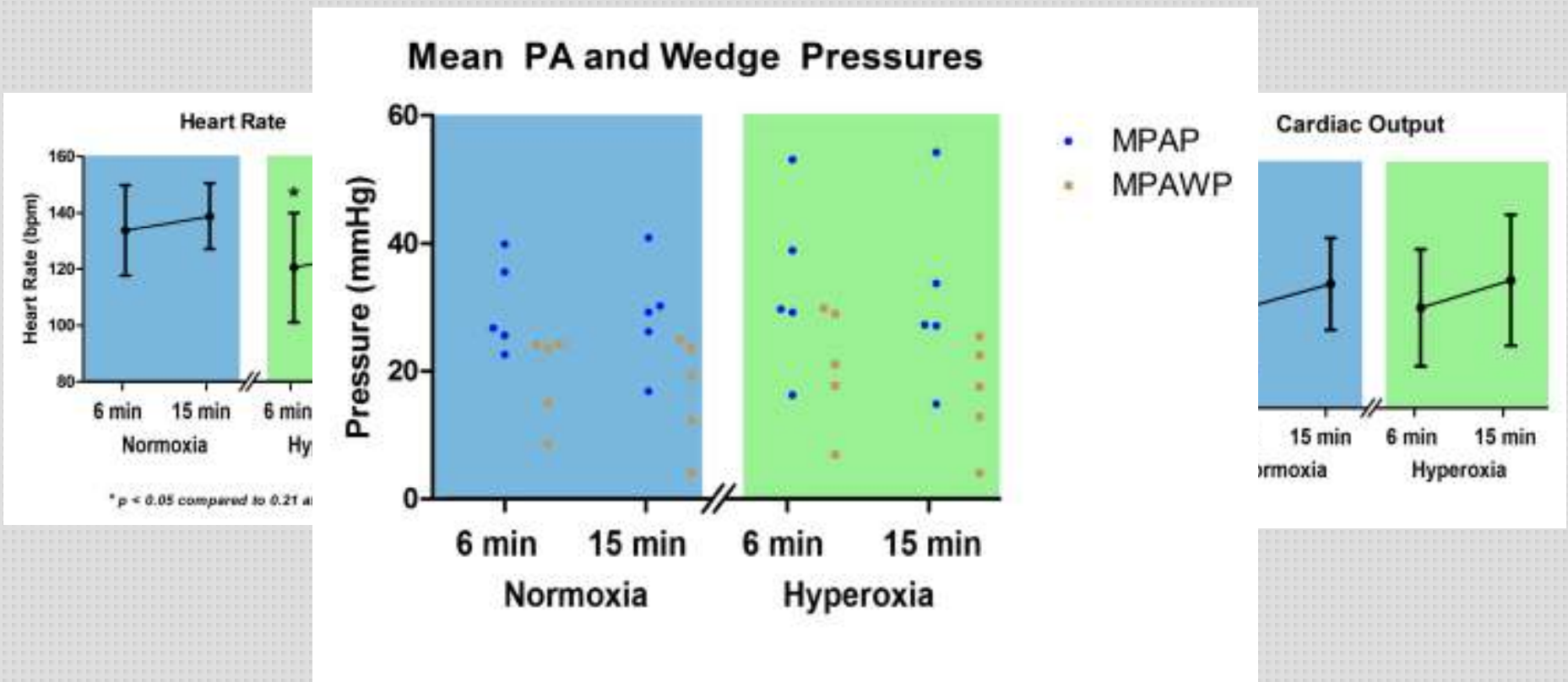
Results (mean \pm SD)



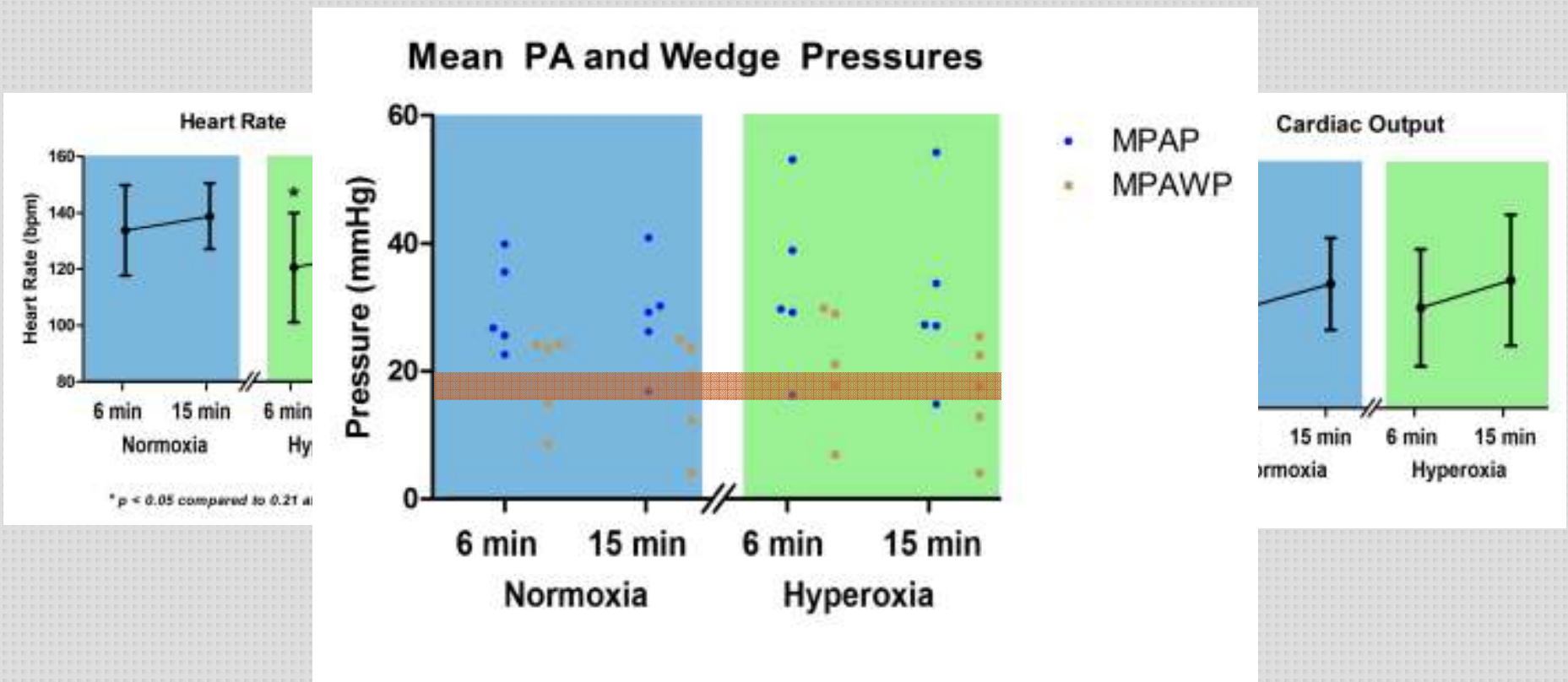
Results: Hemodynamics (mean \pm SD)



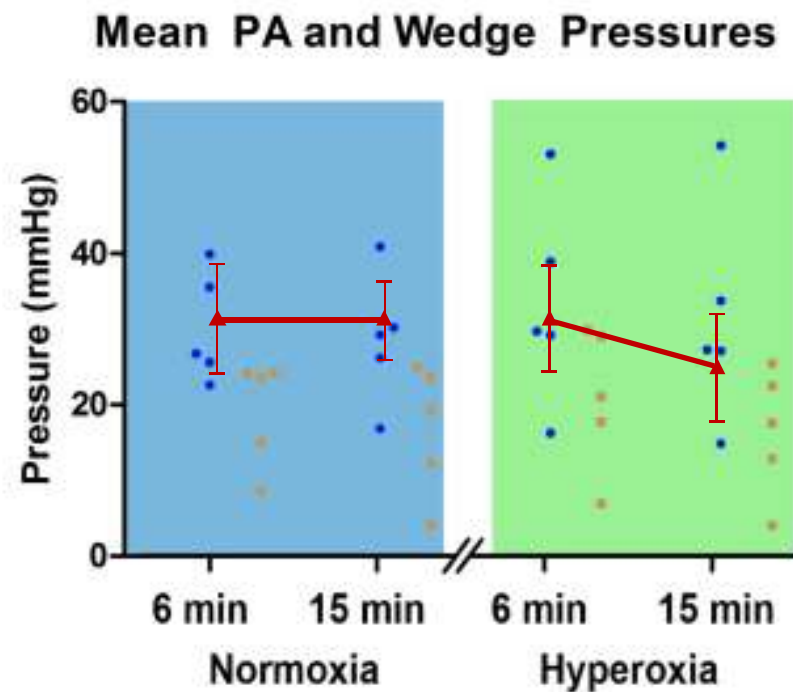
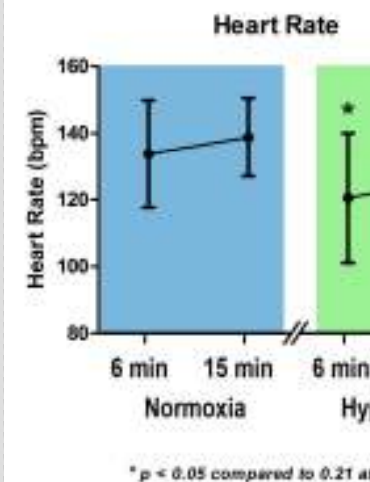
Results: Hemodynamics (mean \pm SD)



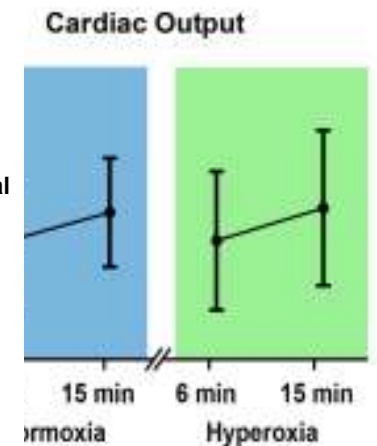
Results: Hemodynamics (mean \pm SD)



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• MPAP
• MPAWP
▲ MPAP in thermoneutral water

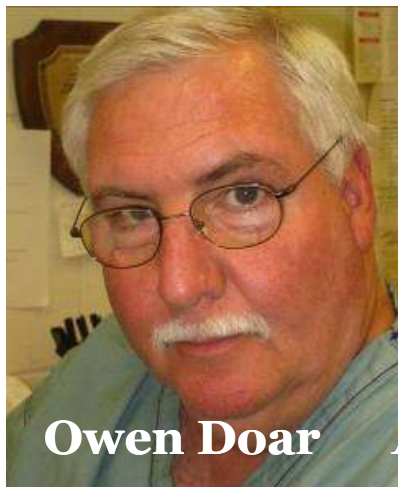


Conclusions

- High PO_2 is associated with
 - Decreased heart rate and ventilation
 - Increased arterial PCO_2
- Confirmed previous findings of high pulmonary vascular pressures during immersed prone exercise in cold water
- PAP and PAWP were not affected by changes in inspired oxygen concentration in cold water

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Owen Doar



Aaron Walker



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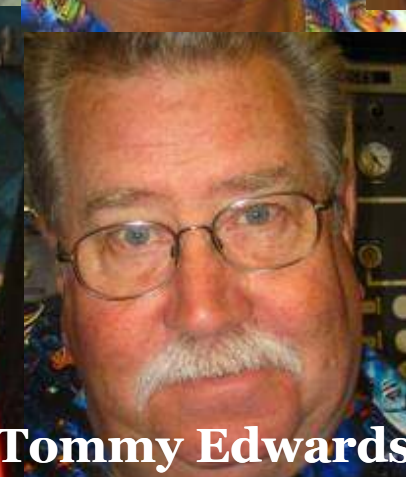
Eric Schinazi



Mike Natoli



Anne Cherry



Tommy Edwards



Richard Moon



Donna Uggucioni



Dawn Kernagis



Sonny Boso



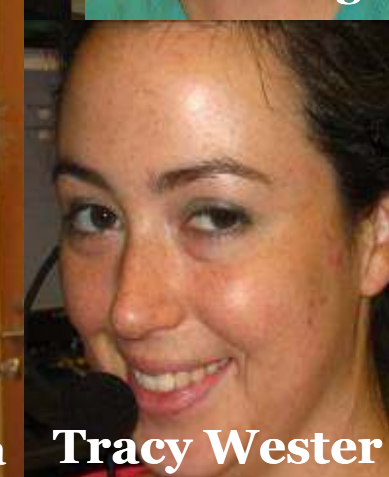
Richard Walker



Iain Beck

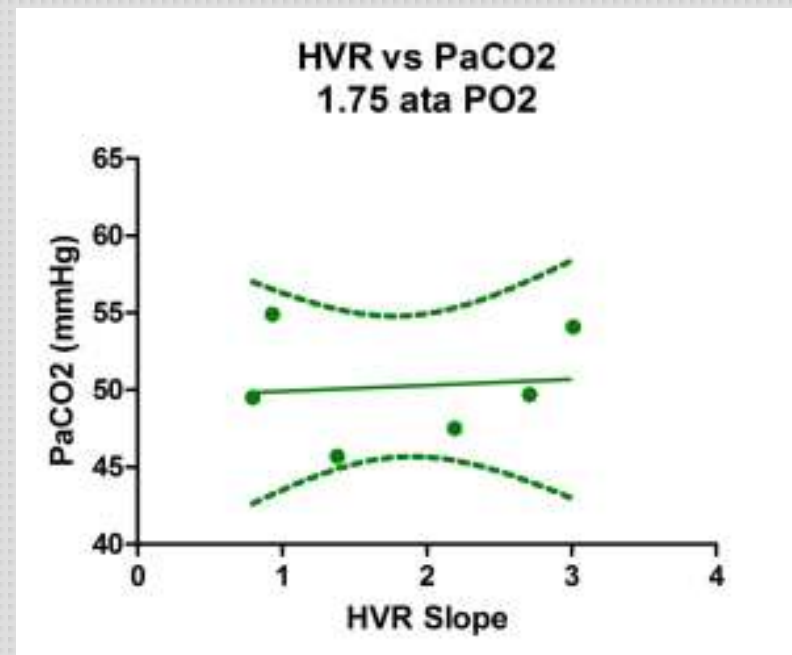
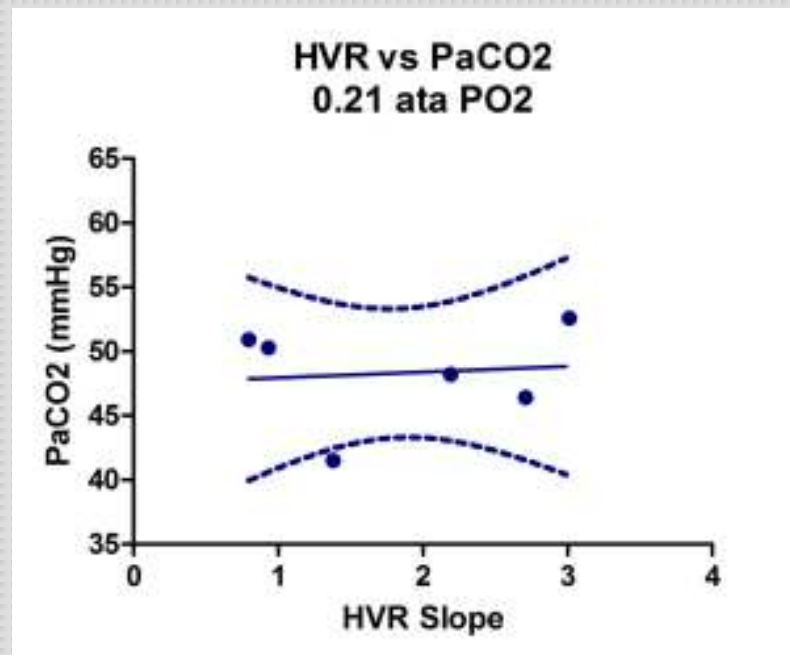


Shelly Pecorella



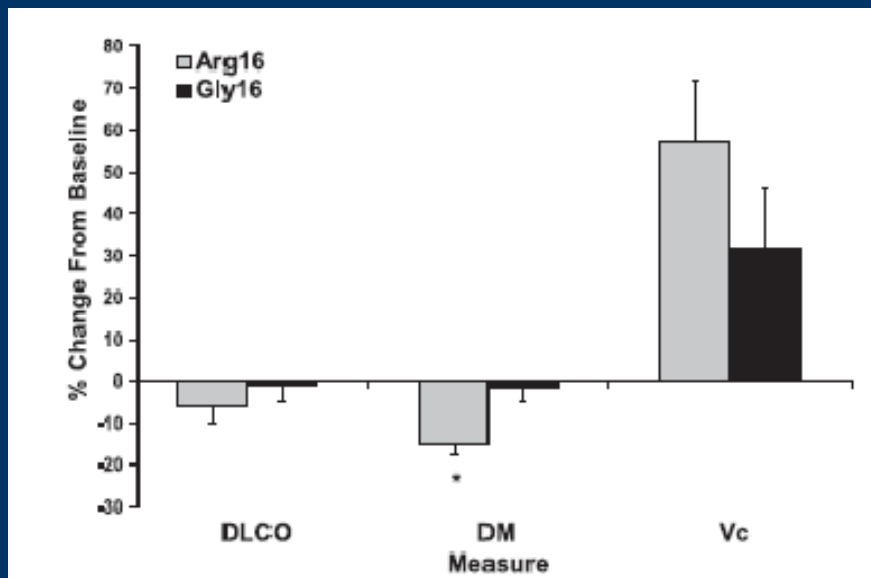
Tracy Wester

Hypercapnic Ventilatory Response

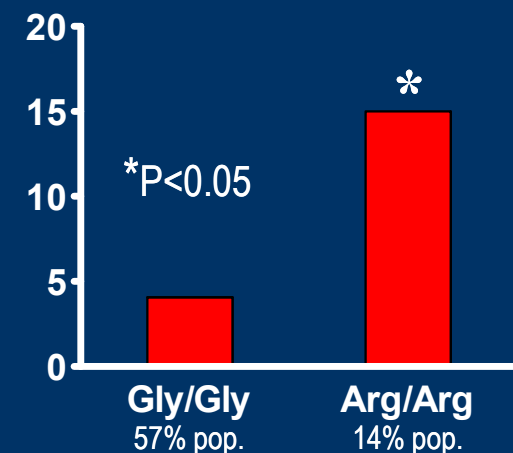


Arg16Gly Polymorphism of β_2 AR and Susceptibility to Pulmonary Edema

NaCl 0.9% 30 mL/kg IV over 15 minutes in healthy volunteers

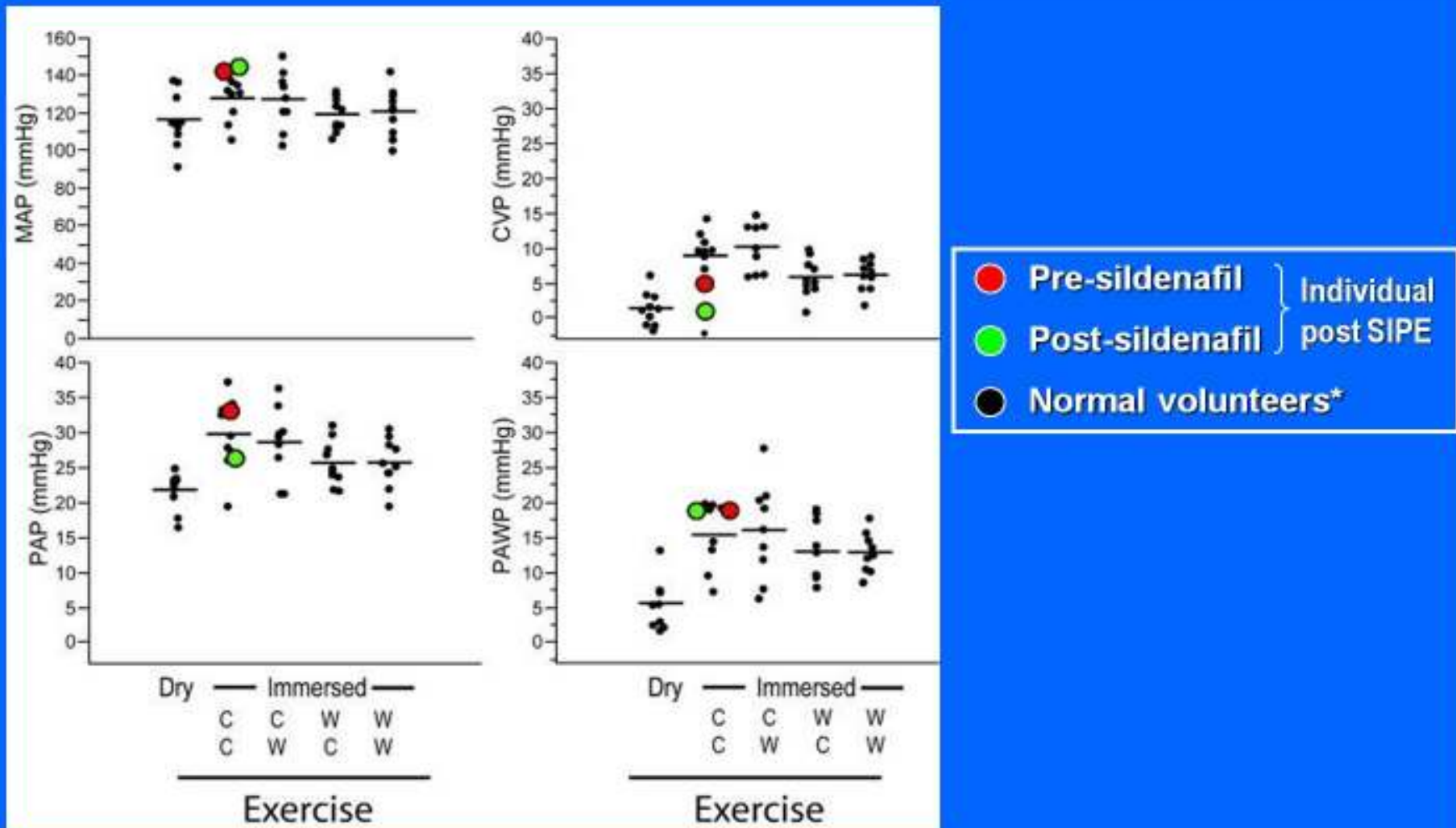


Est
Increase in
Lung
Water (%)



Snyder EM, et al *J Appl Physiol* 102: 2172, 2007

Hemodynamics During 6 min Steady State Immersed Exercise



*From Wester TE, et al. *J Appl Physiol* 106: 691, 2009