# Decompression Stress and the Effects of Osteopathic Manipulative Medicine

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## Introduction

Since the mid-1800's, "decompression disease" or "the bends" has been linked to excess nitrogen in the blood and tissues. While modern dive protocols have reduced the overall incidence of “decompression sickness” (DCS), these outcomes are derived from population-level data. Effective methods to manage individual risk are still largely unknown and remains an active area of research.[1-2]

“Decompression stress” can be described as an asymptomatic physiologic strain on endothelial function resulting from the combined effect of various risk factors for DCS. Multiple studies have explored the effectiveness of pre-dive “preconditioning” interventions on markers of decompression stress, suggesting that altering physiologic conditions before exposure may influence bubble dynamics.[3-5]

Venous gas emboli (VGE) are commonly used as a post-dive indicator of this process. Large retrospective analyses of DCS incidence data have shown that high-grade VGE are positively correlated with severe DCS. More recent studies, however, have demonstrated low specificity due to high intra- and inter-diver variability. We interpret this distinction to be a limitation on the usability of post-dive VGE as a reliable outcome measure in the development of individualized dive protocols.[6-9]

Accurate interpretation of post-dive data is further complicated by physiologic variability, particularly between sexes. Although cohort studies show no consistent baseline difference in DCS incidence, females exhibit higher rates during menses (a recognized physiologic stress state) highlighting the potential influence of dynamic, cycle-dependent factors. To our knowledge, no studies have investigated ovarian cycle-related changes in stroke volume and fluid retention could serve as endogenous markers of physiologic state during decompression.[10-19]

Osteopathic manipulative techniques (OMT) modulate lymphatic, circulatory, and autonomic systems; altering fluid dynamics and potentially influencing decompression-related gas behavior. These effects position OMT as a plausible pre-dive intervention that’s potentially capable of reducing decompression stress at the individual level.[20-22]

## Study Objective

Our project proposes the use of pre-dive osteopathic manipulative techniques (OMT) as a novel continuation of the preconditioning concept due to the known effects of OMT on vascular and lymphatic function. Post-dive VGE will be measured via transthoracic ultrasound alongside additional physiologic markers to better define decompression stress.

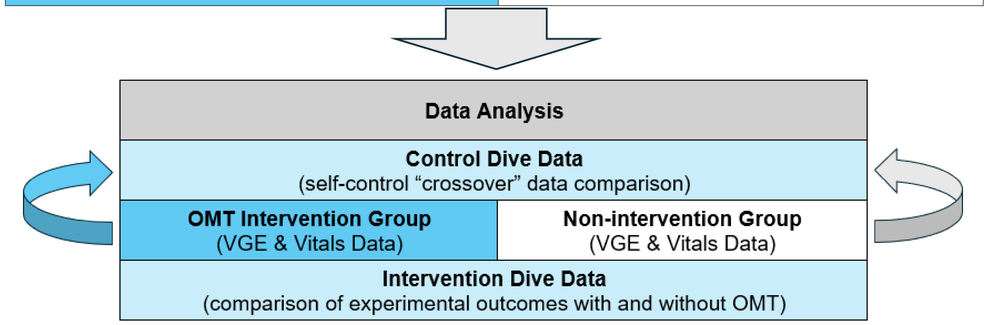
## Hypothesis

**Pre-dive OMT is expected to be associated with lower peak post-dive VGE and reduced variability compared with control dives. Females are predicted to be at lowest risk of developing VGE during lowest water retention, mid-follicular phase, with risk slowly increasing for the next 11 days approaching ovulation, and highest risk during menstruation when water retention is greatest.**

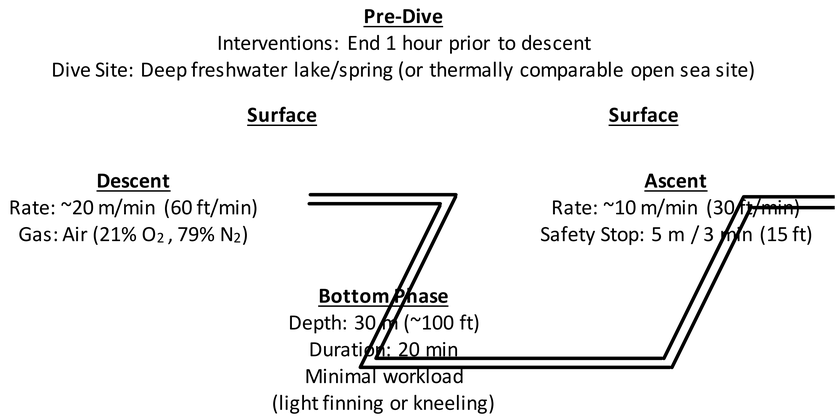
## Experimental Design

➢ A prospective, randomized, controlled, cross-over experimental study using a no-stop open water dive profile.

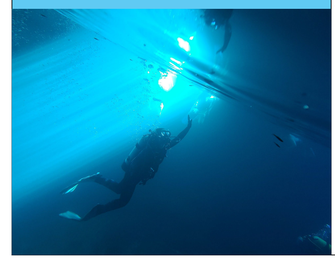
| **Pre-Study Participant Selection** | |
|---|---|
| Pre-Dive Vitals & VGE Scan<br>**Control Dive** (all participants)<br>• Pre-defined dive profile<br>• Collection of self-control (crossover) data<br>Post-Dive Vitals & VGE Scan | |
| **One Week Washout** (all participants) | |
| **OMT Intervention Group** | **Non-Intervention Group** |
| Pre-OMT and Pre-Dive Vitals & VGE Scan | Pre-Dive Vitals & VGE Scan |
| **Intervention Dive** (all participants) | |
| Post-Dive Vitals & VGE Scan | Post-Dive Vitals & VGE Scan |
| Data Collection of OMT Intervention Group | Data Collection of Non-Intervention Group |




## Dive Profile




| **Participant Selection** | |
|---|---|
| **Inclusion Criteria** | **Exclusion Criteria** |
| ❖ Certified divers, ages 18-45<br>❖ Pass general medical clearance for diving.<br>❖ ≥ 50 logged dives.<br>❖ Able to complete a 33 msw, 20 min no-stop air dive.<br>❖ Able to undergo OMT maneuvers (supine, prone, seated).<br>❖ No co-morbidities. | ❖ Does not meet all inclusion criteria.<br>❖ Any prior symptomatic DCS (Type 1-4) with or without medical intervention.<br>❖ Any previous ear barotrauma or chronic sinus condition preventing equalization.<br>❖ Known intracardiac or intrapulmonary right-to-left shunt.<br>❖ Cardiovascular or pulmonary disease, anticoagulation therapy, or regular medications that may alter hemodynamics, endothelial function, or DCS risk.<br>❖ Any absolute or relative contraindications to OMT. |



## OMT Protocol

**Techniques**[20-22]

OMT techniques that modulate lymphatic, circulatory, and autonomic function (altering fluid dynamics relevant to decompression) include:

- Lymphatic pump maneuvers
- Thoracic outlet/inlet release
- Myofascial release (MFR)
- Rib-raising

**Provider Criteria**

- Doctor of Osteopathic Medicine (D.O.).
- Regular use of OMT in clinical practice.

**Documentation**[23-24]

- Standardized osteopathic structural examination (OSE) screening of the 10 anatomical regions.
- AAO Outpatient Osteopathic Cranial SOAP Note Form (version 5 120904).

## References