INTEGRATING STRESS INOCULATION TRAINING AND HEART RATE VARIABILITY BIOFEEDBACK ON ADULT RECREATIONAL SCUBA DIVERS IN A NATURAL DIVE SETTING: A PRELIMINARY PRE- /POST-TREATMENT QUASI-EXPERIMENT

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Introduction
Importance of the Study

The purpose of the study was to explore the effectiveness of an innovative psychophysiological intervention to help scuba divers with a history of high anxiety or panic while diving.

It was hoped the intervention might improve their air consumption and heart rate, improve their ability to effectively problem-solve in the face of underwater stressors, and improve their perceived self-efficacy in the sport and potentially in other parts of their lives.
Conservatively, there are approximately 398,907 active certified recreational divers in the U.S (DEMA, 2017), of which 19% reported a diving incident due to anxiety or panic, and between 19-40% of those were associated with psychological issues (Morgan, 2012).
Importance of the Study


- Triggers – 41% insufficient gas, 20% entrapment, 15% equipment problems,
Importance of the Study


- Disabling agents: 55% emergency ascent, 27% insufficient gas, 13% buoyancy trouble.
Importance of the Study


- Disabling injuries: 33% asphyxia, 29% arterial gas embolism (AGE), 26% cardiac incidents, 5% trauma, 2.5% decompression sickness (DCS), 2.5% unexplained loss of consciousness (LOC), 2% inappropriate gas.
What Was Hoped to be Gained in this Study

Research Questions

- Is there an applied psychophysiological intervention that may have a positive impact on scuba divers who are having difficulties with managing stress while diving, and, if so, in what form?

- Will the combination of a cognitive-behavioral psychotherapeutic approach known as Stress Inoculation Training, and a psychophysiological intervention known as Heart Rate Variability Biofeedback help modulate high anxiety and stress in a recreational scuba diver’s physiology and psychology?

- How does learning to overcome high anxiety and stress in scuba diving from an intervention integrating Stress Inoculation Training and Heart Rate Variability Biofeedback impact an individual’s perceived self-efficacy?
Literature Review
“Iceberg profile of mood states (Anger, Confusion, Depression, Fatigue, Tension, Vigor)” indicating predictability of athletic success in 245 experienced divers, $p<0.05$ (Morgan, 1985),

High anxiety, scores of 39 or higher on the STAI, predicts respiratory distress - hyperventilation - and panic under stressful diving study, $n=45$ college students, $p < 0.001$ (Morgan, Raglin, O'Connor, 2004).
PADI principles to manage stress (increase awareness, recognize stress, emergency action plan, recognize behavior, post-incident processing)

Navy diver training (Burgess, 1983) includes coping strategies for 26 beginning Navy scuba divers using muscles relaxation, concentration, visual imagery, mental rehearsal, and found improved respiration rates in open water tests.

Carpenter, et al. (2018) meta-analysis on efficacy of CBT for acute stress and general anxiety found moderate placebo-controlled effects

Yarbrough (2001) suggests awareness of internal mental states for divers: perception of heart rate, degree of mood state, and general feeling. Defuse problems with proper cognitive processing through psychophysiological preparation and response

Moss & Werthner (2015) suggest CBT combined with HRV biofeedback to improve sporting performance by addressing physiological responses first than address triggers to panic and anxiety

Griffiths, Steel, Vaccaro, & Karpman (1979) study using biofeedback relaxation techniques on 50 novice divers and resulted in decrease in state and trait anxiety

Deikis (1983) examined 71 divers using Stress Inoculation Training and found improvement in state and trait anxiety and improvement in self-efficacy but not statistically significant improvements

Terry, Mayer, & Howe (1998) found mental relaxation training for 44 novice scuba divers to improve state and trait anxiety and competitive state anxiety

Heart Rate Variability Biofeedback and is shown to significantly improve high stress sporting activity performance (Strack & Gevirtz, 2011; Gevirtz, Lehrer, & Schwartz, 2016; Strack, 2003; Raymond, Sajid, Parkinson, & Gruzelier, 2005)

Cohen, Weltman, Ratwani, Chartrand, & McCraty (2010) military application of stress inoculation training VR, and HRVBF for mitigating stress before they are exposed to it
The dive industry is lacking in effective interventions to help highly anxious or panicking scuba divers.

There is an opportunity to contribute original research on an intervention to improve diver safety, their stress coping mechanisms, and their general self-efficacy.

There are prior scuba diver psychological studies that are very old but nothing published that combine stress inoculation training (SIT) with heart rate variability biofeedback (HRVBF) and conducted in the real diving environment (open water).

Literature was reviewed from the present to 1970, searched all major databases for: scuba diver stress, scuba diver anxiety, heart rate variability biofeedback, stress reduction.
Working Hypothesis 1

Participation in five one-hour Stress Inoculation Training sessions integrated with Heart Rate Variability Biofeedback will cause a positive decrease in cardio-respiration measured with:

1) Average airflow in cubic feet per minute (cf/m)
2) Total air tank consumption in pounds per square inch per minute (psi/min)
3) Heart rate in beats per minute (bpm).
Working Hypothesis 2

Participation in five one-hour Stress Inoculation Training sessions integrated with Heart Rate Variability Biofeedback will cause a positive change in mood while scuba diving measured with:
Three factors of the Profile of Mood States (POMS) psychometric assessment:
1. Total Mood Disturbance (TMD)
2. Anxiety (Anx)
3. Vigor (Vig).
Working Hypothesis 3

Participation in five one-hour Stress Inoculation Training sessions integrated with Heart Rate Variability Biofeedback will cause a positive change in self-efficacy while scuba diving measured with:

1. The Generalized Expectancy of Success Scale (GESS).
Methodology
**Study Method Overview**

- **Study design:** Quasi-experimental, single group, pre and post repeated measures

- **Participants:** 9 certified scuba divers

- **Recruitment inclusion:** age 18-65, certified open water diver, willing and time to participate in all training and test dives

- **Recruitment exclusion:** ≤34 on the STAI (State portion), health conditions requiring Dr. consent, will not agree to informed consent, anyone I have a personal relationship with

- **Research setting:** Open-water dive site near Seattle, WA

- **IRB:** Approved by Saybrook IRB

- **Sampling instruments:** Physiological data from respiration sample collected by ScubaPro Gallileo/Luna dive computer with integrated heart rate monitor. Psychological data from the Profile of Mood States (POMS) psychometric instrument and the Generalized Expectancy of Success Scale (GESS)

- **Independent variables:** SIT + HRVBF

- **Dependent variables:** total air consumption, average airflow, average heart rate, total mood disturbance, anxiety, vigor, self-efficacy

- **Data analysis:** Test for outliers, normality, paired t-Test, Cohen’s d effect size
## Procedure Summary

<table>
<thead>
<tr>
<th>Step</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>Four</th>
<th>Five</th>
<th>Six</th>
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<tbody>
<tr>
<td>1</td>
<td>Participant Selection – STAI assessment</td>
<td>Pre-test Dive – POMS &amp; GESS</td>
<td></td>
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<tr>
<td>2</td>
<td></td>
<td></td>
<td>– SIT/HRV (2 sessions)</td>
<td>– SIT/HRV (2 sessions)</td>
<td>– SIT/HRV (1 session)</td>
<td>Post-test Dive – POMS &amp; GESS</td>
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<tr>
<td>3</td>
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</table>
Intervention

Stress Inoculation Training (SIT) (D. Meichenbaum, et al.)

Preparing to mentally confront and handle feelings of being overwhelmed

Adaptive self-statements of involvement in the dive environment

Mental imagery of anxiety producing dive situations (video exposure)

Phases: Conceptualization, skills acquisition and rehearsal, application

5 1-hour training sessions with HRVBF

Heart Rate Variability (HRVBF) (Lehrer, et al., Henriques, et al.)

5 1-hour training sessions with SIT:
1 - Introduction: Assessment, breath shaping, resonant frequency (RF) determination
2 - Practice RF breathing with pacer
3 - Practice RF breathing with pacer
4 - Practice RF breathing without pacer
5 - Practice RF breathing without pacer

Required daily home breathing practice between sessions (20 mins, 2x/day)

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
<th>Session 5</th>
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<tbody>
<tr>
<td>Schedule</td>
<td>Week 1, Day 1</td>
<td>Week 1, Day 2</td>
<td>Week 2, Day 1</td>
<td>Week 2, Day 2</td>
<td>Week 3, Day 1</td>
</tr>
<tr>
<td>Duration</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
</tr>
<tr>
<td>SIT/HRV Treatment</td>
<td>Conceptualization</td>
<td>Skills</td>
<td>Skills</td>
<td>Skills</td>
<td>Application</td>
</tr>
</tbody>
</table>
Intervention Details

Session 1: Assessment
1. Interview
2. Determine Heart Rate Variability Resonant Frequency
3. Evaluate psychosocial, behavioral, and biological factors
4. Determine goals

Session 2: Reconceptualization
1. Psychoeducation of anxiety and stress
2. Introduce Profile of Anxiety Symptoms
3. Introduce Fear Ladder - Introduce the reappraisal concept of the specific diving anxiety by breaking down the anxiety into small steps
4. Introduce thought records and graded exercises (specific to anxiety and panic)
5. HRV Biofeedback for 10-minutes (feedback with problem dives video exposure)

Session 3: Skills-acquisition and skills-consolidation
1. Develop inventory of strengths to cope with anxiety
   a. breathing
   b. attention diversion
   c. relaxation
   d. change maladaptive interpretations
2. HRV Biofeedback for 10-minutes (feedback with problem dives video exposure)
3. Operationalize anxiety while diving by reviewing thought records
4. Introduce thought experiments (alternative thoughts to dive anxiety)

Session 4: Rehearsal and application training
1. Practice coping skills with imaginable situations
2. HRV Biofeedback for 10-mins without pacer (feedback with problem dives video exposure)
3. Role reversal exercise (participant plays role of therapist and therapist plays role of participant) and teach therapist how to use CBT to deal with diver anxiety

Session 5: Generalization and maintenance
1. HRV Biofeedback for 10-minutes without pacer (feedback with problem dives video exposure)
2. Apply to skills to other anxieties in life through guided exercise, imaginable and behavioral rehearsal
3. Develop plans on thoughts, behaviors, emotions of a variety of stressful diving situations and stressful life situations
4. Ensure self-attribution has taken place:
   a. What did you do?
   b. How did you handle the situation this time differently than how you handled it last time?
   c. When else did you do this?
   d. How did that make you feel?
Instruments

**SELF-EVALUATION QUESTIONNAIRE: STAI Form Y-1**

*Please provide the following information:*

Name: ___________________________  Gender (Circle)  M  F  Date: ____________

**Age:________ Gender:________ Gender:________**

**DIRECTIONS:**

A number of statements which people have used to describe themselves are given below. Read each statement and circle the appropriate number to the right of the statement to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

1. **I feel calm:**  1  2  3  4
2. **I feel secure:**  1  2  3  4
3. **I am tense:**  1  2  3  4
4. **I feel strained:**  1  2  3  4
5. **I feel at ease:**  1  2  3  4

**MODERATELY SO**

**NOT AT ALL**

**VERY MARKED**

**GENERALIZED EXPECTATION SCALE**

Please print your name ___________________________ Date and Time ____________

This is a questionnaire to find out how people will do in certain situations. Each item consists of a 5-point scale and a belief statement regarding one’s expectations about events. Please indicate the degree to which you believe the statement would apply to you personally by writing the appropriate number next to the statement:

1 = Highly Unlikely
2 = Extremely Unlikely
3 = Neither likely or unlikely
4 = Likely
5 = Highly Likely

**In the future I expect that I will:**

**Succeed at most things I try**

**Be listened to when I speak**

**Carry through my responsibilities successfully**

**Get the promotions I deserve**

**Have successful close personal relationships**

**Handle unexpected problems successfully**

**Make a good impression on people I meet for the first time**

**Invent the career goals I set for myself**

**Experience many failures in my life**

**Have a positive influence on most of the people with whom I interact**

**Be able to solve my own problems**

**Acquire most of the things that are important to me**

**Find that no matter how hard I try, things just don’t turn out the way I would like**

**Handle myself well in whatever situation I’m in**

**Reach my financial goals**

**Resolve all problems working with others**

**Discover that the good life outweighs the bad**

**Be successful in my endeavors in the long run**

**Be unable to accomplish my goals**

**Be very successful working out my personal life**

**Succeed in the projects I undertake**

**Discover that my plans don’t work out too well**

**Achieve recognition in my profession**

**Have rewarding intimate relationships**

**Total** ___________________________
HRV Biofeedback

Using the BVP sensor

The BVP sensor does not require skin preparation as it is placed directly in contact with the skin. Place the sensor against the fleshy part of the first part of any finger and hold it in position using the elastic strap.

Optimizing placement

The BVP sensor is sensitive to light, movement, and pressure. To prevent artifacts caused by light interference, be careful to adjust the two small openings on the sensor’s front so they are firmly pressed against the finger pad and there is no gap between the black edges of the sensor and the skin. If the client’s fingers are too small, it is recommended to place the sensor on the thumb pad.

Pressing the sensor too firmly against the finger pad will decrease the sensitivity of the signal because excessive pressure reduces blood circulation in the finger tip. Look at the raw signal when adjusting the sensor against the finger pad and try to maximize the signal amplitude.

While using the BVP sensor, instruct the client to keep their arms and hands as immobile as possible. This is made easier by having them rest their hands on their thighs, palm side up.

Using the respiration sensor

To place the respiration sensor, unclip the strap and attach it around the client’s abdomen so that the sensor is in the front. The belt should be snug enough that the strap stays fixed when the subject is relaxed.

Ask the client to breathe out fully and tighten the sensor slightly at full expiration. This should provide enough slack in the elastic strap to allow it to stretch without being overstretched when the abdomen expands.

The video plays when all the bars graphs are green.

Cardiovascular - HRV power training
Results
### Demographics and Environment

<table>
<thead>
<tr>
<th>Experimental SIT + HRVBF</th>
<th>Gender</th>
<th>Age</th>
<th>State</th>
<th>Trait</th>
<th>Training Duration (days Pre-Post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>Male</td>
<td>25</td>
<td>53</td>
<td>43</td>
<td>14</td>
</tr>
<tr>
<td>Participant 2</td>
<td>Male</td>
<td>30</td>
<td>68</td>
<td>27</td>
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<tr>
<td>Participant 3</td>
<td>Male</td>
<td>33</td>
<td>68</td>
<td>27</td>
<td>14</td>
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<tr>
<td>Participant 4</td>
<td>Male</td>
<td>50</td>
<td>73</td>
<td>36</td>
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<td>Participant 5</td>
<td>Male</td>
<td>30</td>
<td>60</td>
<td>60</td>
<td>21</td>
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<tr>
<td>Participant 6</td>
<td>Male</td>
<td>62</td>
<td>42</td>
<td>38</td>
<td>21</td>
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<tr>
<td>Participant 7</td>
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<td>27</td>
<td>66</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Participant 8</td>
<td>Male</td>
<td>33</td>
<td>60</td>
<td>43</td>
<td>14</td>
</tr>
<tr>
<td>Participant 9</td>
<td>Male</td>
<td>33</td>
<td>68</td>
<td>35</td>
<td>28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Temperature (Fahrenheit)</th>
<th>Diving Time (Minutes)</th>
<th>Air Tank Type</th>
<th>No. Private Office Training Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkai Cove 1 or 2</td>
<td>M=54.9, SD=2.6</td>
<td>M=23.1, SD=11.2</td>
<td>Steel 80 or Steel 100</td>
<td>M=5.0, SD=0.0</td>
</tr>
</tbody>
</table>
Data Analysis and Distribution

- SPSS v.24
- No boxplot values greater than 1.5 box lengths from the edge of the box
- Shapiro-Wilk test for normality (normal distribution when sig. > 0.05)

<table>
<thead>
<tr>
<th>Tests of Normality</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>df</td>
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<tr>
<td>Difference in pre-post air flow</td>
<td>.184</td>
<td>9</td>
</tr>
<tr>
<td>Difference in pre-post air consumption</td>
<td>.185</td>
<td>9</td>
</tr>
<tr>
<td>Difference in pre-post POMS Anxiety subscale</td>
<td>.153</td>
<td>9</td>
</tr>
<tr>
<td>Difference in pre-post POMS Vigor subscale</td>
<td>.154</td>
<td>9</td>
</tr>
<tr>
<td>Difference in pre-post heart rate</td>
<td>.162</td>
<td>9</td>
</tr>
</tbody>
</table>

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction
Hypothesis 1 (decrease in cardio-respiration) – Air Flow

Paired samples t-test
M = -.25333 cf/min, 95% CI[-.31337, -.19330], t(8) = -9.731, p < .0005, d = -3.24
Hypothesis 1 (decrease in cardio-respiration) – Air Consumption

Paired samples t-test
M = -19.47778 psi/min, 95% CI[-25.23789, -13.71767], t(8) = -7.798, p < .0005, d = -2.59
Hypothesis 1 (decrease in cardio-respiration) – Heart Rate

Paired samples t-test
M = -13.111 bpm, 95% CI[-19.850, -6.372], t(8) = -4.486, p=.002, d = -1.49
Hypothesis 2 (positive change in mood) – Total Mood Disturbance

Paired samples t-test
M = -16.444, 95% CI[-22.185, -10.704], t(8) = -6.606, p < .0005, d = -2.20
Hypothesis 2 (positive change in mood) – Anxiety

Paired samples t-test
M = -24.667, 95% CI[-32.139, -17.194], t(8) = -7.612, p < .0005, d = -2.53
Hypothesis 2 (positive change in mood) - Vigor

Paired samples t-test
M = 13.667, 95% CI[5.523, 21.811], t(8) = 3.870, p= .005, d = 1.29
Hypothesis 3 (positive change in self-efficacy) – GESS

Paired samples t-test
M = 17.667, 95% CI[9.660, 25.673], t(8) = 5.088, p = .001, d = 1.69
Discussion
The Intervention Shows Promise for Highly Anxious/Panicking Recreational Scuba Divers

- The study positively identified several applied psychophysiological interventions to help scuba divers:
  - Relaxation training, cognitive restructuring, and physiological awareness.
  - The study did not determine if this intervention is specifically effective or not compared to other interventions for scuba divers.

- The study found the intervention might help modulate high stress in scuba divers.
  - The study did not determine if the intervention is specifically effective for modulating high stress in divers.

- The study found the intervention might help increase an individual’s self-efficacy.
  - The study did not determine if the intervention is specifically effective for increasing self-efficacy in divers.
Potential Mechanisms of the Intervention

The exact mechanisms on the intervention are unknown. However:

- It can be speculated the autonomic nervous system (ANS) can be modulated to decrease symptoms of stress (anxiety and/or panic) with HRVBF, creating a pathway to new adaptive thoughts, beliefs, and positive emotions by increasing vagal tone (Polyvagal theory – Porges, 1994).

- HRVBF has shown to alter autonomic function, restore homeostatic autonomic balance, increase homeostatic regulation, and improve emotional and somatic symptoms affected by the ANS (Vaschillo, et al., 2006).

- Indirectly, HRVBF may influence inflammatory and emotional processes through vagal-inflammatory pathways and stimulation of the brainstem structures involved in emotional control, and directly affecting respiratory gas exchange efficiency by controlling phase relationships between heart rate and breathing (Gevirtz, Lehrer, Schwartz, 2016).

- SIT adopts a transactional view of stress and coping (Lazarus and Folkman, 1984) model that suggest stress occurs whenever the perceived demands of the situation tax or exceed the perceived resources of the individual to meet those demands, especially when the individual’s well-being is judged or perceived being at stake. This mechanism emphasizes the role of cognitive-affective appraisal process and coping activities. Stress can also have a constructive narrative perspective.
Comparison of Findings to Other Studies

**POMS**

**Raglin, Stegner (2005) Study**

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<th>Anx</th>
<th>Dep</th>
<th>Ang</th>
<th>Vig</th>
<th>Fat</th>
<th>Conf</th>
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<tbody>
<tr>
<td>Panic Profile</td>
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<tr>
<td>Norm Profile</td>
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<td>43</td>
<td>45</td>
<td>59</td>
<td>40</td>
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</table>

**POMS (this study)**

**Imber (2018) Study**

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<th>Anx</th>
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<th>Ang</th>
<th>Vig</th>
<th>Fat</th>
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<tr>
<td>Post-Test</td>
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<td>45</td>
<td>42</td>
<td>59</td>
<td>39</td>
<td>41</td>
</tr>
</tbody>
</table>
Delimitations and Limitations

- Results may not be generalizable to other highly stressed populations.
- Participants experienced only one type of intervention.
- The researchers style and demeanor could have influenced participant reactions.
- The dive site was selected to control for environmental factors, but the site was not a typical open-water dive site.
- Diving time was shortened to a maximum of 40 minutes compared to normal dive times of 60 minutes.
- The study did not attempt to determine learning effects or optimal number of treatment sessions.
- The study focused exclusively on anxiety and panic induced by scuba diving, however there may have been confounds of other comorbid conditions in each participant.
- Warmer water diving climates may produce different results.
- There was no control group to compare pre/post differences to determine efficacy.
- The size of the study was small.
- No conclusions can be made about gender or age differences.
- Measuring changes in mood and self-efficacy during the dive was impractical so these were measured immediately after the dive with reflected memory of mood and self-efficacy during the dive.
Clinical Research Implications

- Results of the study indicate future research on the effects of mind-body stress mitigation interventions would be fruitful.

- Replicating this study with control/comparison groups would be worthwhile.

- Extending this study’s application to other populations experiencing high stress and having difficulty coping with it could be important research.

- The study highlights the probability that highly stressed individualized have non-pharmacologic treatment options.

- This study indicates that scuba divers with high anxiety (or panic) can experience lower levels of these symptoms, longer dive times, greater safety, and increased self-efficacy.

  - In can be speculated that the cognitive-behavioral approach of SIT supplemented with HRVBF provides an integrated psychophysiological approach divers can use to cognitively mediate and cope with high stress.

  - Participants of this study seemed to engage the mind-body intervention to improve their diving, as well as, improve their daily lives.

  - The intervention may be applicable for other highly stressed populations because high stress tends to invoke similar psychophysiological reactions as an individual may encounter in other life situations.
Conclusion

- The study indicated by the participants’ outcomes that SIT + HRVBF is a feasible treatment option in modulating the symptoms of high anxiety (or panic) induced by stress during recreational scuba diving.

- Participants experienced significant physiological and psychological improvements.

- It is hoped that this study will support perspective that non-prescription medication options exist to manage high stress and its resulting symptomology.

- It is hoped that future research will use this study as a basis to further test this and similar interventions.

- It is hoped future research will reveal more about the mind-body connections with respect to psychophysiological phenomenon and associated mechanisms of human stress.

“I could barely submerge without panicking in the swimming pool, and shortly after your course treatment, I went diving in the Channel Islands, CA. I had a fantastic time, saw lots of wild life, and the dive guide told me I was an excellent new diver. Thank you so much for what you did for me!” – study participant