

The Synergistic Effect of Hyperbaric Oxygen and Virtual Reality Exposure Therapy on Mild Traumatic Brain Injury with Post-Traumatic Stress Disorder

Introduction

From 2001-2014, as many as 320,000 American soldiers returned home from Iraq and Afghanistan with mild traumatic brain injury (mTBI) (Bandak et al., 2015). mTBI is caused by a bump or blow to the head and results in disruption to normal brain function (Elder et al., 2012). The most common cause of mTBI for American soldiers is blast injury (Blennow et al., 2011). PTSD is a psychological disorder caused by trauma (Elder et al., 2012). Soldiers are five times as likely to have PTSD if they have suffered a mTBI. Hyperbaric oxygen therapy (HBOT) is a medical treatment in which a patient is exposed to 100% oxygen in a contained, pressurized environment (Liu et al., 2010). It reduces cerebral edema in mTBIs (Obenaus, 2011). VRET is a technology-based exposure therapy that has been shown to reduce anxiety (Wang & Li, 2013). There is not currently a treatment for both mTBI and PTSD.

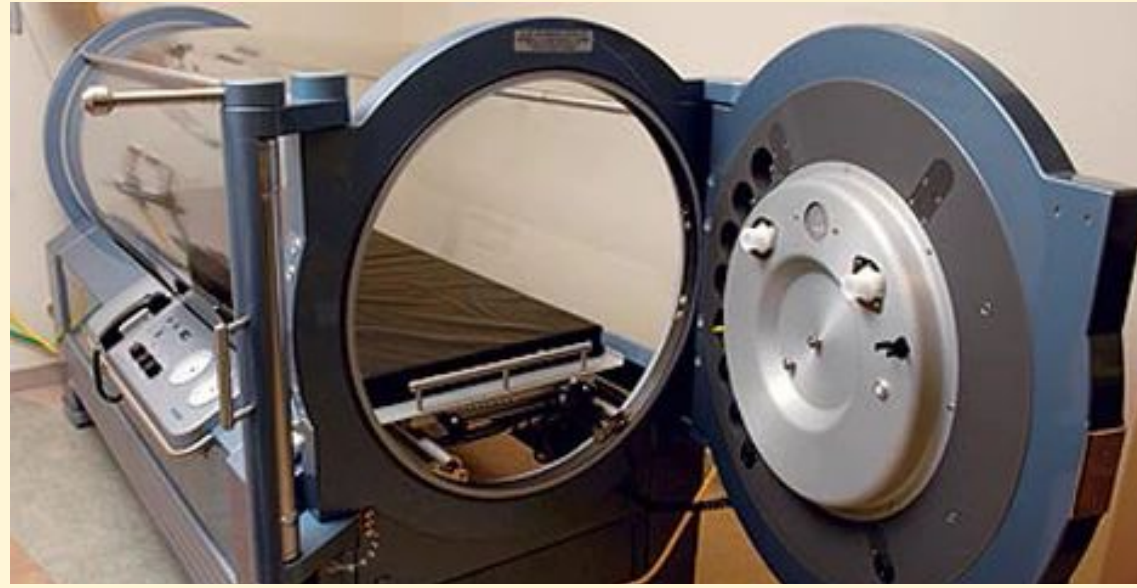


Figure 1: Image of a hyperbaric oxygen chamber (Mayo, 2016).

Purpose

The purpose of this study is to explore the validity of the synergistic effect of hyperbaric oxygen and virtual reality exposure therapy on mild traumatic brain injury with post-traumatic stress disorder.

Methods

Data was collected from various peer-reviewed papers and analyzed using systematic data analysis. The papers were found through various online databases. All data in this study was extracted from peer-reviewed studies no more than ten years old to ensure current research. Additionally, the subjects tested in these studies were all current/past members of the American military in OEF, OIF, and/or OND. Paired t-tests for the initial research question were performed in Microsoft Excel to determine if the data was significant.

Research Question

Is there a synergistic effect between hyperbaric oxygen and virtual reality exposure therapy on the treatment of mild traumatic brain injury with post-traumatic stress disorder in soldiers?

Hypotheses

Alternative: The combination of HBOT and VRET will have a significant effect on mTBI with PTSD in soldiers.

Null: The combination of HBOT and VRET will not have a significant effect on mTBI with PTSD in soldiers.

Abstract

Mild traumatic brain injury (mTBI) has dramatically affected the lives of many American soldiers. mTBI is often exacerbated by post-traumatic stress disorder (PTSD). Despite this, there is no current treatment for both mTBI and PTSD. Hyperbaric oxygen therapy (HBOT) and virtual reality exposure therapy (VRET) were both investigated in this study as a possible synergistic treatment for the combined diagnosis of mTBI and PTSD present in many American soldiers. Data was collected through a systematic literature review using online databases. Data analysis involved a paired T-test. Data obtained indicated that HBOT was effective in treating mTBI symptoms, but it was ineffective in treating PTSD as quantified by the Clinician Administered PTSD Scale (CAPS) ($p=0.6330$). However, VRET was shown to be significant in reducing CAPS scores ($p=0.0014$). There were no studies available testing the effectiveness of both HBOT and VRET concurrently, so further work is needed to confirm that the combination of both can be used to treat both mTBI and PTSD.

Results

The Effect of Virtual Reality Exposure Therapy on CAPS Scores

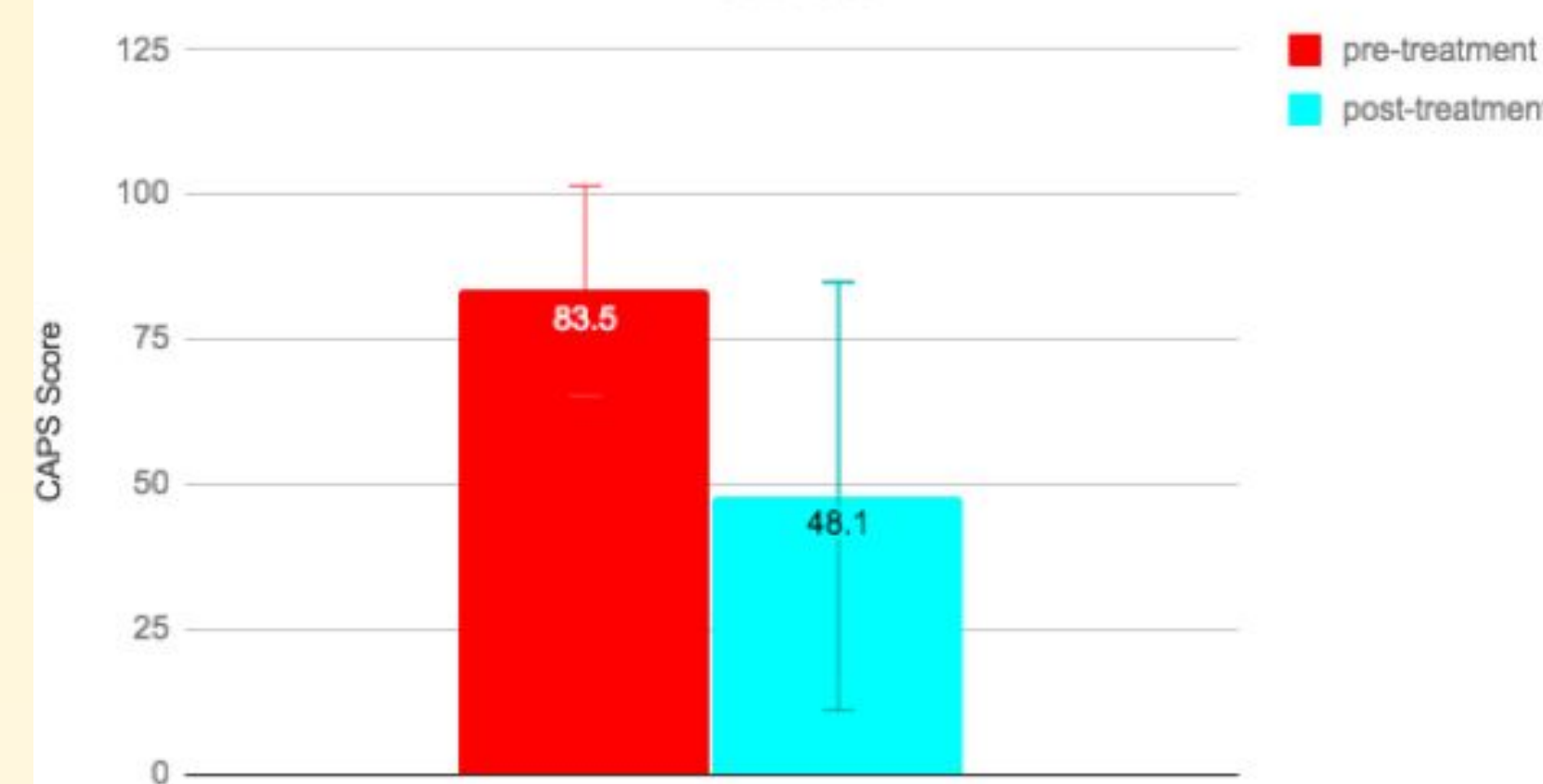


Figure 7: The effect of virtual reality exposure therapy on CAPS scores. Bars indicate standard deviation *shows significant difference ($p=0.0014$)

This data was extracted from a sample size of twenty total subjects from six total studies. Not all patients experienced all of the following symptoms, so there is a different patient size for each symptom. The table includes the percentage of subjects that indicated that a particular symptom improved, did not change, or declined following HBOT treatment. The fractions inside the parentheses following the percentages indicate the number of subjects that indicated that a particular symptom improved, did not change, or declined following HBOT treatment out of the total subjects that experienced the specific symptom. Following HBOT treatment, almost all symptoms improved. Most symptoms improved over 70% following HBOT. The p-values for all but 3 symptoms were significant with a value of over 0.05.

Table 1. The effect of HBOT on specific symptoms of mTBI as self-reported by patients

Symptom	Improved	No Change	Declined	p-Value
Headache	80% (12/15)	20% (3/15)	0% (0/15)	0.0140
Sleep disruption	93% (14/15)	7% (1/15)	0% (0/15)	0.0001
Memory	72% (13/18)	28% (5/18)	0% (0/18)	0.0500
Cognition	94% (15/16)	6% (1/16)	0% (0/16)	0.0001
Energy level	80% (8/10)	20% (2/10)	0% (0/10)	0.0500
PTSD stress	20% (1/5)	80% (4/5)	0% (0/5)	0.2080
Irritability	73% (8/11)	27% (3/11)	0% (0/11)	0.1377
Photophobia	67% (6/9)	33% (3/9)	0% (0/9)	0.3466

Results

The Effect of Hyperbaric Oxygen Therapy on CAPS Scores

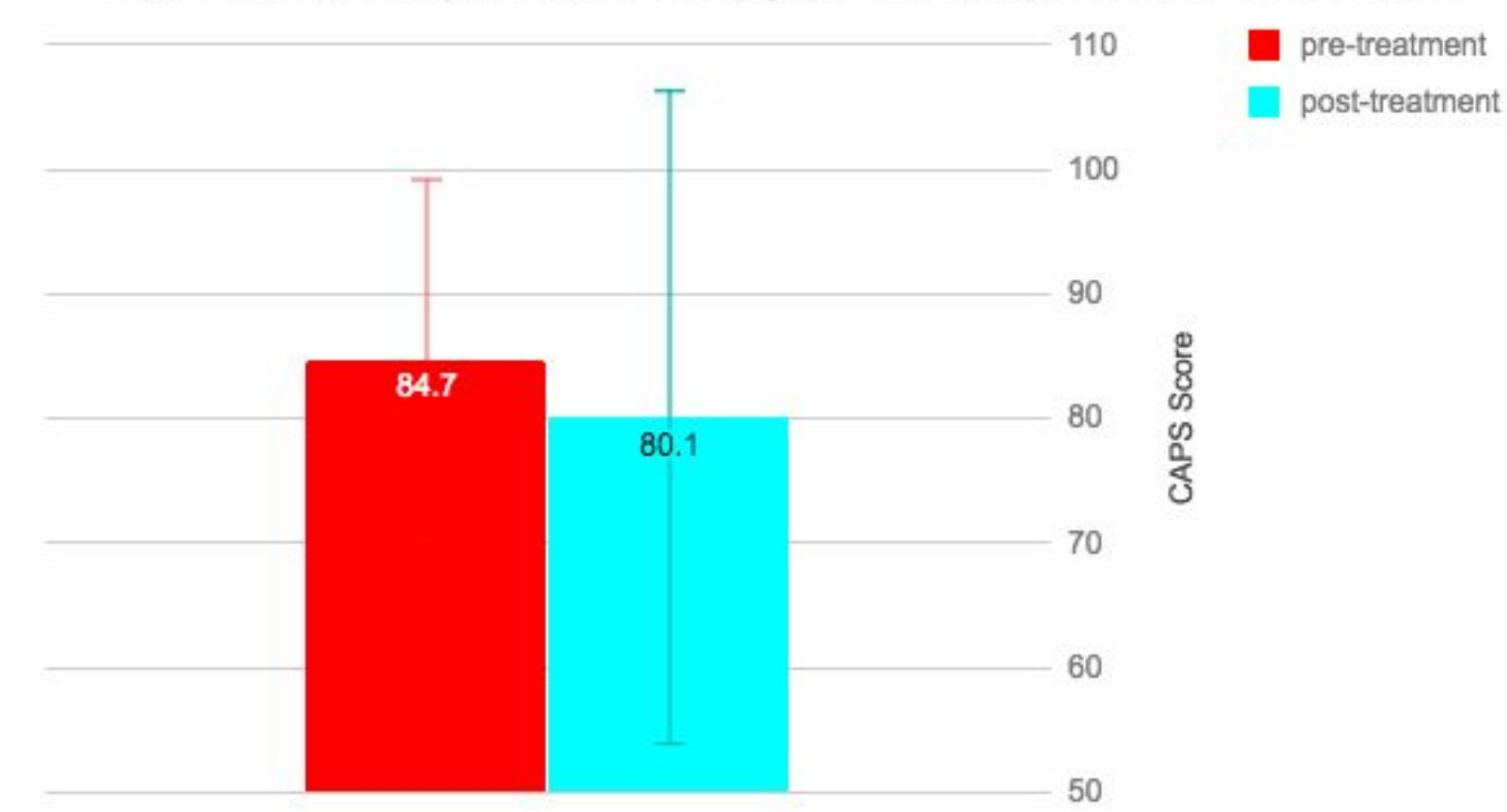


Figure 6: The effect of hyperbaric oxygen therapy on CAPS scores. Bars indicate standard deviation *shows insignificant difference ($p=0.663$)

This bar graph indicates the effect of HBOT on CAPS scores. CAPS scores were collected and averaged from six studies with a total of 20 subjects across all studies. Before treatment, the average CAPS score was 84.7, with a standard deviation of 14.1. After HBOT treatment, the average CAPS score was reduced to 80.1, with a standard deviation of 26.2. The p-value was 0.663, meaning the effect of HBOT on CAPS scores was insignificant.

This bar graph indicates the effect of VRET on CAPS scores. CAPS scores were collected and averaged from five studies with a total of 16 subjects across all studies. Before treatment, the average CAPS score was 83.5, with a standard deviation of 14.1. After HBOT treatment, the average CAPS score was reduced to 48.1, with a standard deviation of 36.9. The p-value was 0.0014, meaning the effect of VRET on CAPS scores was significant.

Discussion

The combination of HBOT and VRET pose as a possible treatment for mTBI and PTSD. HBOT has been shown to be effective in reducing cerebral edema, brain swelling that can be caused by mTBI. By providing oxygen to the brain, unoxygenated neurons and blood vessels become oxygenated, reducing cerebral edema. This explains why symptoms such as headache, memory loss, and low energy level were improved after HBOT treatment because they were a direct result of the cerebral edema. However, PTSD typically causes changes in the brain such as increased activity in the amygdala and decreased activity in the hippocampus and PFC. HBOT has not been researched in repairing damaged neural structures that were not damaged by lack of oxygen. As a result, HBOT had no effect on PTSD symptoms because the treatment is not an effective way to treat the root cause of the disorder. The changes in the brain as a result of VRET have not been researched. However, as a result of this paper, it can be hypothesized that VRET decreases the activity of the amygdala and increases the activity of the hippocampus and PFC. These structures are typical damaged in those with PTSD. Since VRET had such a significant effect in reducing CAPS scores, it is highly likely it influenced brain activity in such a way.

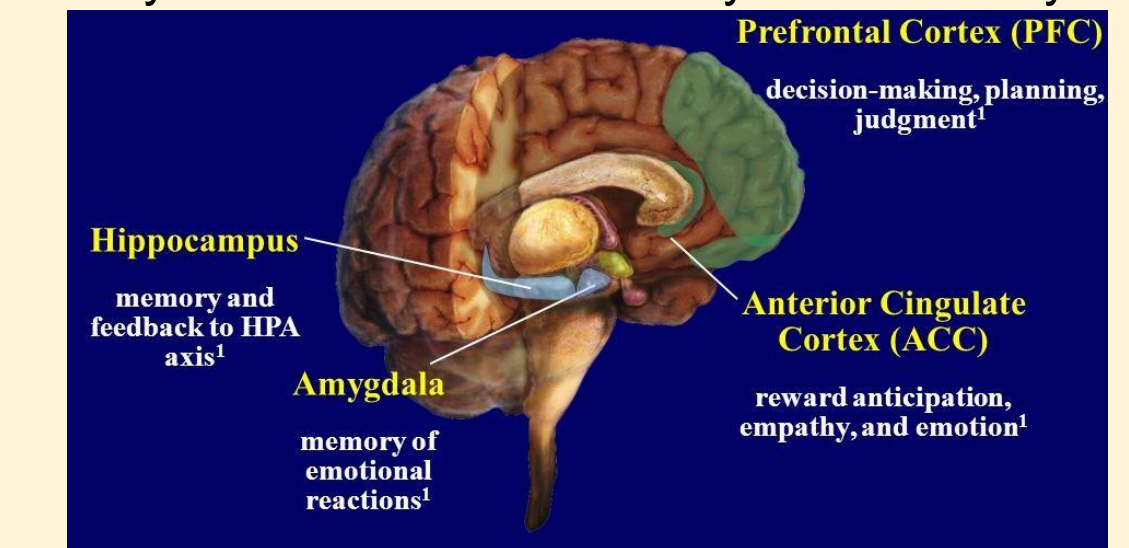


Figure 2: Areas of the Brain Implicated in PTSD (Charney et al., 2004)

Conclusion

HBOT reduces most symptoms of mTBI except for PTSD stress. This result is confirmed by a lack of significance of HBOT on CAPS scores post-treatment. However, VRET does have a significant effect on lowering CAPS scores post-treatment. The two treatments should be looked at as a possible treatment option for soldiers/veterans currently suffering from both mTBI and PTSD to increase their quality of life and to reduce negative long-term effects.

Future Work

The studies investigated in this paper either focused on solely HBOT or solely VRET. To accurately judge whether or not there is a synergistic effect between the two, a study needs to be conducted in which patients with mTBI and PTSD are treated with both treatments concurrently.

Acknowledgments

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