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Utilizing new technologies to measure therapy effectiveness for mental and physical health

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UTILIZING NEW TECHNOLOGIES TO MEASURE THERAPY EFFECTIVENESS FOR MENTAL AND PHYSICAL HEALTH

by

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ABSTRACT

Mental health is quickly becoming a major policy concern, with recent data reporting increasing and disproportionately worse mental health outcomes, including anxiety, depression, increased substance abuse, and elevated suicidal ideation. One specific population that is especially high risk for these issues is the military community because military conflict, deployment stressors, and combat exposure contribute to the risk of mental health problems.

Although several pharmacological approaches have been employed to combat this epidemic, their efficacy is mixed at best, which has led to novel nonpharmacological approaches. One such approach is Operation Surf, a nonprofit that provides nature-based programs advocating the restorative power of the ocean and surfing. Although the limited research in this area has shown a positive impact on the health of veterans, these results were based on self-reported survey instruments that suffer from a series of well-known biases. Fortunately, the recent introduction of wearable technology (e.g., Whoop bands) that unobtrusively gather physiological data such as heart rate variability (HRV), resting heart rate (RHR), and both rapid eye movement (REM) and deep sleep, offers an opportunity to validate or invalidate traditional survey assessment data.

This study used survey data to measure changes in depression, anxiety, and posttraumatic stress disorder (PTSD), together with data generated from Whoop bands, and qualitative data, producing a more robust set of programmatic efficacy inferences for military veterans who participated in Operation Surf between 2021–2022. Paired samples *t* tests were used to analyze the data gathered before the intervention, immediately after, and 1 month later. Survey scores before the therapy, as measured by the psychometrically sound PHQ-8 (depression), PCL-5 (PTSD), and GAD-7 (anxiety), were significantly higher than both time points after therapy,

revealing statistically significant and clinically significant decreases in anxiety, depression, and PTSD symptoms. Physiological data indicated varying degrees of statistically significant change in HRV, RHR, REM sleep, and deep sleep, while the qualitative data provided supported the quantitative findings.

Taken together, the introduction of physiological data gathered from wearable technology can hopefully further understanding toward a low-cost, scalable treatment modality while eliminating stigmas and barriers to care for military veterans and informing public policy care decisions.

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CHAPTER 1: INTRODUCTION

As the COVID-19 global pandemic entered its 3rd year of existence in 2022, concerns for mental health and the many associated conditions it exacerbated continued to increase in terms of both need and cost of care. Although prepandemic research from 2019 suggested there were an estimated 51.5 million adults aged 18 or older in the United States with mental illness, representing 20.6% of all United States adults (Merikangas et al., 2010; Substance Abuse and Mental Health Services Administration, 2020), there is concern the numbers have since increased. For example, the Centers for Disease Control and Prevention reported a series of disproportionately worse mental health outcomes for the United States in 2020, including increased substance use and elevated suicidal ideation. Specifically, 11% of U.S. adults considered suicide and an alarming 40% said they were struggling with mental health or substance abuse (Czeisler et al., 2020).

Although the COVID-19 global pandemic has foregrounded many of these mental health concerns, the notion of both mental and physical trauma is hardly new; international political conflict, war, and domestic issues such as rape and abuse can create trauma. For instance, as of 2014, 1 in 5 Americans had been sexually molested, 1 in 4 had been beaten, and 1 in 3 couples had been involved in physical violence (van der Kolk, 2014). In addition, as of 2010, one quarter of the U.S. population had alcoholic relatives and 1 in 4 women and 1 in 7 men had experienced severe physical violence by an intimate partner (Black et al., 2011). Although humans are certainly a resilient species capable of rebounding from such things as war and violence, traumatic experiences do leave traces on human minds, biology, and immune systems (van der Kolk, 2014).

Mental health is quickly becoming a major concern globally due to the prevalence and impact it has on community, society, and health in individuals, both in reach and severity (Czeisler et al., 2020). Although many different populations are impacted by mental health conditions, one specific population that is especially high risk for mental health conditions and substance abuse is the military community, both active duty and veterans, due to the events they witness during combat. In fact, many military members who return from deployment have a difficult time adjusting to civilian life due to the impact of their experiences in these conflicts, causing functional and social disruption and impacting them through mental health issues such as posttraumatic stress disorder (PTSD), which is a condition triggered by experiencing or witnessing a terrifying event (Benninger et al., 2020; Crawford, 2016; Milliken et al., 2007; Oman & Bormann, 2015; Rogers et al., 2014). PTSD can cause depression, anxiety, anger, sadness, and lower levels of self-efficacy (Crawford, 2016), which is the belief in an individual's ability to influence events that affect their life and control over the way these events are experienced (Bandura, 1994).

In particular, PTSD manifests itself through the symptoms of reexperience, avoidance, negativity, and hyperarousal, which can cause sleep disturbance and other issues (National Institute of Mental Health, 2020). *Reexperiencing* involves reliving the memories of a traumatic event, producing the same feeling of horror and fear as the actual experience. *Avoidance* causes the individual to avoid situations that remind them of the traumatic event, which could lead to avoiding crowds or even driving in a car if there was an accident or if their military convoy was bombed. *Negativity* can involve negative changes in beliefs and feelings in the way an individual thinks about themselves and others following the traumatic experience. *Hyperarousal* may cause an individual to maintain a high sense of alert for dangerous situations, often with emotions of anger and irritability, causing sleep disturbances and trouble concentrating; this level of alert can occur over something as benign as a loud noise. Thus, PTSD can cause difficulty with interpersonal relationships, diminished psychological resilience and self-efficacy, poorer mental health and physical functioning, and an increased risk of suicide (Crawford, 2016; Jakupcak et al., 2007; Milliken et al., 2007; Oman & Bormann, 2015; Pietrzak et al., 2009; Vasterling et al., 2009).

Although PTSD extends far beyond the military, affecting about 8 million U.S. adults in a given year, the problem is especially acute among war veterans (Reisman, 2016). Military conflict, deployment stressors, and combat exposure all contribute and grow the risk for mental health problems such as PTSD, depression, and anxiety. Even without a physical injury, a veteran could develop a mild to severe case of PTSD and the associated symptoms, which could create daily dysfunction and the need for treatment to improve quality of life and well-being (Radomski & Brininger, 2014). Extended deployments, higher rates of survival from wounds, and exposure to multiple improvised explosive device blasts specific to the Iraq and Afghanistan wars have contributed to higher rates of PTSD in veterans from these wars (Seal et al., 2009; Tanielian & Jaycox, 2008).

As a result of PTSD, many military veterans face difficulty with interpersonal relationships, exacerbated by their lack of patience, aggression, and even overt hostility (Jakupcak et al., 2007). Significant health consequences such as suicidal ideation, mortality, and medical/psychological comorbidities can cause difficulties, such as job loss, divorce, loss of productivity, increased substance abuse, participation in illegal and or risk-taking activities, and even suicide (Adler et al., 2011; Elbogen et al., 2010; Killgore et al., 2008; Iverson et al., 2013). Not surprisingly, these conflicts cause a significant increase in the use of health care services, while the cost of care continues to rise. The U.S. Department of Veterans Affairs (VA) analyzed 55 million veterans' records from 1979 to 2014 and found an average of 20 veterans die from suicide per day (Office of Suicide Prevention, 2016).

A veteran's transition to civilian life is not easy, evidenced by comparatively low employment rate, where the veteran employment rate is 46.8%, lower than the 63.2% rate for civilians (U.S. Bureau of Labor Statistics, 2021). The difficulty of readjustment and reintegration not only hampers veterans' relationships and affects their families, but it can also affect their communities and occupations (J. A. Gonzales & Simpson, 2021). Many veterans have reported their military service, skills, or leadership positions do not necessarily translate into civilian life, which can lead to frustration and a diminished well-being and sense of purpose, or worse, suicide (Caddick & Smith, 2014; Rogers et al., 2014). Veterans dealing with PTSD can experience trouble with alcohol or drug abuse; feelings of shame, hopelessness, and despair; harsh physical symptoms; career and employment problems; divorce among married couples; and physical violence (Dekel & Monson, 2010; Javidi & Yadollahie, 2012). These behaviors do not occur in a vacuum; they impact not only the veteran, but also their family, friends, caregivers, and even their local community and society as a whole. The behavioral avoidance symptoms of PTSD can make routine daily activities, such as spending time with friends or taking part in school parties or kid's programs, difficult (Solomon et al., 1993). The costs associated with these behaviors are financial, relational, and often cause family strain, affecting every facet of veterans' lives. Even secondary trauma can have an impact; research has suggested veterans' children are more likely to have behavioral problems such as increased anxiety and aggression (Dekel & Monson, 2010).

The sheer volume and scope of mental health issues, exhibited by the number of affected individuals and through the concomitant economic, financial, and relational costs and strains, necessitates further investigation into various treatment modalities (Black et al., 2011; Crawford, 2016; Czeisler et al., 2020; Radomski & Brininger, 2014; Reisman, 2016; van der Kolk, 2014). In addition to standard medical treatments involving prescription drugs used to treat PTSD, complementary and alternative medicine (CAM) refers to a group of health care systems, practices, and treatments that are not considered to be a part of conventional medicine (Libby et al., 2012). Survey data have shown the use of CAM for the treatment of mental and emotional problems in general—and PTSD in particular—have been increasing significantly (Barnes et al., 2008; Rakel et al., 2008). For instance, acupuncture, massage therapy, service companion dogs (i.e., pet therapy), healing touch, yoga, nature and environment therapy (e.g., ocean and surf therapy), and even the use of cannabis and psilocybin (i.e., psychedelics) are joining a growing list of CAM options. In fact, many recent studies and findings have documented positive benefits of these options, which supports more research (Cavanaugh & Rademacher, 2014; Johnson et al., 2018; Lakkireddy et al., 2013; O'Haire & Rodriguez, 2018; Srinivasan et al., 2018). Public perception, and even legislation changes—such as the decriminalization and legalization of the use of cannabis and psychedelics such as psilocybin and ketamine—also pave the way for additional research (A. K. Davis et al., 2021; Feder et al., 2020; Slomski, 2021).

There has been a resurgence of clinical research on psilocybin substances, reflecting a shift in the popularity and destigmatization of psilocybin, which has both motivated and been amplified by recent policy changes such as the decriminalization of psilocybin (Yaden & Griffiths, 2021). Several jurisdictions have approved psychiatric substances, including the apparently imminent approval for psychiatric use in several contexts across North American and Europe. Additionally, some studies have suggested psychedelics may demonstrate substantial efficacy for serious psychiatric conditions such as mood and substance use disorders (Carhart-Harris & Goodwin, 2017; Mithoefer et al., 2016; Tullis, 2021; Yaden & Griffiths, 2021).

One positive aspect in times of uncertainty is people may be willing to try new approaches, especially approaches that do not involve any form of traditional medication (Rogers et al., 2014; Wynn, 2015). One such nondrug approach is Operation Surf, a nonprofit that develops programs that seek to provide results-driven, nature-based programs advocating the restorative power of the ocean and surfing as a form of wellness for injured bodies, minds, and souls (Operation Surf, n.d.-c). Through these programs, the hope is to give veterans confidence and overcome the pain and trauma they have experienced. Operation Surf came into existence through a desire to share the gift of surfing and help heroes overcome the pain and mental trauma of war. This nonprofit offers week-long, world class, instructor-led adventures for wounded veterans and active-duty military heroes, bringing them to the west coast and exposing them to the healing power of the ocean through surfing. These all-inclusive events provide an environment where participants work to overcome perceived limitations connected to their physical and psychological disabilities. The goal of the program is to instill hope and confidence. Operation Surf channels the healing powers of the ocean to restore hope, renew purpose, and revitalize community. Through a weeklong immersive surf camp, they use the power of the ocean and compassionate mentorship to instill hope, helping wounded military heroes overcome everyday challenges and transform their outlook on life.

Previous quantitative research on ocean therapy using data gathered from survey instruments have indicated a significantly positive impact on veterans, showing a reduction in PTSD symptoms, reduced depression, and an increase in self-efficacy among veterans with PTSD in the United States (Crawford, 2016). Understanding the processes of ocean therapy could help veterans who experience difficulty transitioning to civilian life due to struggles with interpersonal relations and risky or illegal sensation-seeking activities such as alcohol, drugs, speeding, and other thrill-seeking behaviors (Diehm & Armatas, 2004; Roberti, 2004; Rogers et al., 2014). Through ocean therapy, these issues could be addressed as veterans learn patience and confidence in nature and obtain the sought-after adrenaline rush through surfing (Crawford, 2016).

This type of nature-based therapy has shown significant promise as a therapeutic approach; researchers have suggested outdoor exposure that includes recreational pursuits such as surfing and fishing, coupled with opportunities for social interaction with peers, may be beneficial to Armed Forces veterans experiencing PTSD (Bennett et al., 2017; Wheeler et al., 2020). For instance, Bennett et al. (2017) found veterans participating in nature-based therapy experienced significant decreases in symptoms of PTSD, depression, perceived stress, and functional impairment, and an increase in leisure satisfaction. Physical activity in the natural environment may have an especially potent influence on mental health, providing greater benefits than physical activity alone, specifically on tension, anger, and depression (Thompson Coon et al., 2011; Walter, Otis, Ray, et al., 2019). In fact, one multistudy analysis demonstrated exercise outdoors in the presence of water—versus without water—generated greater improvements in overcoming symptoms associated with depression (Barton & Pretty, 2010).

Surf therapy has emerged as a growing therapeutic intervention in diverse communities around the world in the decade from 2010 to 2020 and studies have supported surf therapy as a means of improving both physical and psychosocial health outcomes (Caddick & Smith, 2014; Crawford, 2016; Hignett et al., 2018; Rogers et al., 2014; Walter, Otis, Ray, et al., 2019). However, there is a need for more evidence-based research to further understand its physical, psychological, and social benefits (Benninger et al., 2020). Importantly, advancements in technology allow the ability to monitor and improve personal health and performance using wearable technology and mobile applications (M. Wu & Luo, 2019). These devices extend the ability to collect human physiological biomarker data, unobtrusively gathering fitness, sleep, and recovery data through wearable technology hardware. Previously, ascertaining these data was extremely limited due to the requirement of large, expensive, nonmobile machines, usually reserved for large hospitals and medical organizations, which prevented outdoor, remote, field use.

Smart watches, bands, garments, and other wearable technology, often called *wearables*, use embedded sensors, along with other technology such as photoplethysmography, accelerometers, and global positioning systems to record and capture data, informing and providing users with feedback on various physiological markers (Bayoumy et al., 2021). Photoplethysmography is an uncomplicated and inexpensive optical measurement method that is often used for heart rate monitoring purposes; specifically, this noninvasive technology uses a light source and a photodetector at the surface of the skin to measure the volumetric variations of blood circulation (Castaneda et al., 2018). Through the measurement of such things as cardiorespiratory function, heart rate, sweat analysis, tissue oxygenation, and sleep, individuals have an increased ability to manage and improve health outcomes such as PTSD. Wearable devices provide data and feedback guiding personal health insights in real time, potentially driving behavioral change that could improve health and life in general. Given the severe impact of the debilitating condition of PTSD to an increasing number of individuals, the need for objective, comprehensive, and rigorous research has never been more important.

Problem Statement

Veterans face high rates of PTSD and suicide (Hester, 2017) and many veterans must work to overcome perceived limitations connected to their physical and psychological disabilities. Although research has suggested between 7%–8% of the general population in the United States experience PTSD in their lifetimes, as many as 16% of deployed U.S. military personnel might experience PTSD symptoms (Dursa et al., 2014; Gates et al., 2012; Judkins et al., 2020). PTSD has a variety of symptoms leading to higher rates of comorbidity conditions of alcohol and drug abuse, despair, feelings of hopelessness and shame, and job problems, plus relationship issues such as physical violence toward friends and family (Javidi & Yadollahie, 2012). Combat veterans often substitute illegal risk-taking behaviors (e.g., drugs, reckless driving, unsafe sex, gambling, alcohol abuse) to obtain the adrenaline rush they felt while fighting in combat (Adler et al., 2011; Elbogen et al., 2010; Killgore et al., 2008; Myrseth et al., 2012; Thomsen et al., 2011; Wilk et al., 2010). Mental health agencies are constantly looking for ways to motivate veterans to take part in therapeutic activities that do not involve pharmaceuticals, alcohol, or illegal drugs (Rogers et al., 2014). High-intensity sports such as surfing, snowboarding, and rock climbing may provide a socially acceptable alternative to risk-taking behavior such as speeding and substance abuse, and sports such as surfing may result in an elevated, positive mood (Diehm & Armatas, 2004; Pittsinger & Liu, 2010; Roberti, 2004).

Due to the aforementioned downstream effects, there is a substantial cost associated with PTSD to individuals, their families, and society (L. L. Davis et al., 2022). These costs manifest themselves in several ways, including: (a) financial costs of medical care, including mental health treatment and increased use of health care services; (b) physical health consequences; and (c) loss of productivity through work impairments. Financially, costs have been high and nearly doubled for active-duty military personnel, from $468 million in 2007 to $994 million in 2012 alone (Blakeley & Jansen, 2013). Costs that are harder to quantify include: (a) a burden and strain on relationships; (b) stress from risk taking and sensation seeking; (c) alcohol and drug abuse; and (d) even suicide and death, with the ultimate price being a loved one's life (Cuijpers & Smit, 2002; Dekel & Monson, 2010; Sachinvala et al., 2000; Tanielian & Jaycox, 2008).

Veterans also face a range of personal, societal, and logistical barriers to accessing care, such as long wait times and cultural stigmas (Misra-Hebert et al., 2015). Not surprisingly, veterans have a higher burden of illness than civilians (Luncheon & Zack, 2012), but fewer than one third of individuals deployed to Iraq or Afghanistan since 2001 have used VA healthcare services (Spelman et al., 2012). Issues of stigma and not being able to ask for help have been identified as barriers to seeking treatment (Blais & Renshaw, 2013; Elnitsky et al., 2013; Interian et al., 2012; Keane et al., 2013; Mittal et al., 2013; Stecker et al., 2013; Zinzow et al., 2013). Some of the more widespread, standard psychological treatments often used to treat PTSD include cognitive behavioral therapy and prolonged exposure therapy, which involve revisiting past traumas and can cause intense anxiety for clients, often leading to treatment output (Motta, 2020). There is conflicting evidence on relative benefits of these types of psychological treatments; additionally, high nonadherence rates for medication can also reduce treatment effectiveness, increasing the risk for relapse and further justifying interest in other interventions (Bulloch & Patten, 2010; Cuijpers et al., 2010; Geddes et al., 2003; Papakostas et al., 2008).

Although prescription drugs and psychotherapy have been somewhat beneficial to veterans, they may want to feel like they are taking action rather than simply ingesting medicine or talking about their psychological trauma (Nichols, 2014). Existing options for antidepressant treatments are limited by their delayed onset of action, lack of efficacy, and adverse outcomes (aan het Rot et al., 2009). Importantly, studies have suggested alternative therapies and nature-based programs (e.g., surfing organizations such as Operation Surf) can help veterans restore confidence and hope (Crawford, 2016). Although existing research is limited, quantitative data captured through self-report surveys found measurable improvement in combatting these ailments, such as PTSD, depression, and anxiety. Interviews with Operation Surf participants seemed to indicate the program was time well spent. A smaller, nonrandomized study also suggested a sports-oriented occupational therapy intervention can show potential as an intervention for veterans seeking mental health treatments for PTSD (Rogers et al., 2014). Furthermore, Caddick and Smith (2014, 2017) and Caddick et al. (2015a, 2015b) produced strong, qualitative data through several peer reviewed journal articles indicating similar benefits.

Further exploration of alternative therapies is warranted. Specifically, ocean and surf therapy should be further explored for its potential to improve health outcomes, improve quality of life, and help restore enjoyment of everyday activities in the military veteran population. Adding physiological data to self-reported survey assessments, coupled with qualitative field observations and thematic analysis, will create more systematic, full spectrum data with potential consequences of reducing the financial cost burden of care, removing barriers to care and stigmas associated with receiving care, reducing strain on relationships, and increasing safety through reduction in physical harm through need for risk (e.g., gambling, speeding, drinking), and a reduction in death and suicide. This endeavor could also raise critical funds for additional research and treatment. Such studies are especially needed to raise awareness and understanding of these affordable, shorter-term programs with strong ability to scale, providing much-needed incentives and resources for exploration.

This study sought to build upon the data and research conducted by Crawford (2016) with Operation Surf, in conjunction with a smaller, nonrandomized study (Rogers et al., 2014) and other surf therapy research projects (Walter, Otis, Ray, et al., 2019), which have suggested a sports-oriented occupational therapy intervention has potential. This study examined the impact of surf therapy psychologically, physically, and psychosocially using surveys, physiological biomarkers, and qualitative data. Using wearable technologies through a partnership with Whoop bands can give researchers the ability to collect new data, specifically data gathered outside the laboratory in field settings, while also providing an opportunity to validate self-reported assessment data. These additional data will also inform future research designs, produce data-driven insights to encourage better behaviors and improve health outcomes, and further understanding and identification of appropriate treatment options and cost-effective solutions.

Study Purpose

The purpose of this mixed methods study was to collect data for analysis and insight using new technologies to measure therapy effectiveness. Specifically, this study sought to understand how Operation Surf's weeklong ocean surf therapy program impacted psychological, physical, and functional outcomes for veterans seeking mental health treatments for symptoms of PTSD. More specifically, this study examined the impact the experience had on self-reported levels of PTSD, depression, and anxiety through administering surveys and gathering additional quantitative physiological data through biofeedback mechanisms in wearable technology. The physiological data served two purposes: (a) to understand to what extent attending the event correlated with change in participants' biomarkers and (b) to compare the biomarker results with the self-reported survey data.

Conducting qualitative research also helps to include the voice of the participant, resulting in greater insight and understanding of the overall experience. It can also produce a verbal description of why changes, if any, occur. Finally, this research can help uncover what programmatic changes might be beneficial for longer lasting results. Qualitative research offers the ability to generate more detailed descriptions of the impact than is possible to obtain through only quantitative measures. Although the quantitative data will be primary for generating diagnostic scores that can be compared over time and the intervention, they cannot capture the detail and complexity of veterans' experiences of mental health in the way that qualitative methods allow. Involving participants allows a better understanding on their quality of life, allows them to share critical thoughts about interventions and engagement, and also allows the researcher ability to work with veterans to design better solutions, enhancing the relevance and application of research findings (Caddick & Smith, 2017; Wells et al., 2016). Qualitative research might also be useful for countering a focus on pathology, such as by capturing the full range of emotions and benefits that may arise from taking part in this exercise (Caddick & Smith, 2017). Importantly, the qualitative data could also help to explain any discrepancy between the self-reported survey data and the physiological data and contextualize the results and further understanding.

Research Questions

The research questions of this study were formulated to evaluate the impact of participating in an ocean therapy program for veterans with PTSD, through assessing psychological symptoms (e.g., PTSD, depression, anxiety) and monitoring physiological biomarkers (e.g., heart rate variability [HRV], resting heart rate [RHR], rapid eye movement [REM] sleep). The research questions were:

- Research Question 1: To what extent, if any, is there a change in PTSD symptoms, depression, or anxiety among veterans who participate in Operation Surf as measured by the PTSD Check List (PCL-5) assessment, the Patient Health Questionnaire Eight (PHQ-8), and the General Anxiety Disorder Scale (GAD-7), at three points in time?
- Research Question 2: To what extent, if any, is there a change in physiological biomarker data among veterans who participate in Operation Surf?
- Research Question 3: To what extent, if any, does the qualitative data help explain any discrepancies in the quantitative data from the first two research questions?

Significance of the Study

Although veterans who suffer from PTSD have been examined in the research literature, several treatments that might be most effective for them have not been thoroughly discussed or researched. More specifically, using ocean therapy as a treatment modality, exercise as medicine, and blue space interventions for health and well-being addressed the importance of the ocean therapy application to military veterans with PTSD. These interventions could help them cope, help to restore hope, and act as a catalyst for them to construct an alternative narrative of their life experience (Rogers et al., 2014; Walter, Otis, Ray, et al., 2019).

This research was significant because the results and findings could allow military veterans to reduce their PTSD symptoms, including depression and anxiety. These symptom reductions may help their families because PTSD can put strain on intrapersonal relationships (e.g., lack of patience, aggression, overt hostility) and their community (Crawford, 2016). The results of this study demonstrate support for ocean therapy as beneficial for veterans with PTSD and suggests a new treatment modality that could increase the quality of life for PTSD afflicted veterans, their families, and their friends and peers, but more research is necessary to further understand.

This treatment could also reduce the barriers to care such as eliminating the stigma of receiving care or asking for help. Reduction in PTSD symptoms, depression, and anxiety could reduce the number of suicides. Using surf therapy could reduce the overall cost of care if it is demonstrated to be a repeatable, scalable, and affordable treatment.

The data from this study, specifically the physiological data, could also inform public policy care decisions and enrich the decision-making process globally, especially as mental health increasingly comes into the spotlight. Lastly, comparing the self-report survey assessment data with the physiological biomarker data could help to validate or invalidate the survey instruments that are widely used and widely accepted. This study did not gather enough data to validate or invalidate completely, but they did demonstrate feasibility to execute data collection; however, further research is necessary to further understanding.

Surveys are easily distributable but limited by subjective bias and require subjects to revisit trauma and pain. Unobtrusive data collection through wearables could yield new insights while effectively eliminating biases. Taken together, understanding the processes of ocean therapy could help veterans who experience difficulty transitioning to civilian life because of struggles with interpersonal relations and risky or illegal sensation-seeking activities such as drinking, alcohol, drugs, speeding, and other thrill-seeking behavior (Diehm & Armatas, 2004; Roberti, 2004; Rogers et al., 2014). Through ocean therapy, these issues could be addressed as the veteran learns patience and confidence in nature and obtains the sought-after adrenaline rush through surfing (Crawford, 2016).

CHAPTER 2: LITERATURE REVIEW

In this literature review, I discuss mental health, existing treatments, and alternative therapies for posttraumatic stress disorder (PTSD). Specifically, I look at the mental health diagnosis of PTSD through history, causes, prevalence, and populations impacted (e.g., military veterans). This examination of PTSD also includes the costs, specifically in terms of care, burdens, finances, and harm (e.g., increased suicide rate).

Specifically for this study, I examined the U.S. Department of Veterans Affairs' (VA) four types of symptoms, behaviors, activities, and issues exhibited in people who have PTSD, such as (a) sensation seeking and risk taking, (b) criminal behavior, (c) substance abuse from a legal perspective, and (d) the strain on intrapersonal relationships. All these factors deeply affect individuals with PTSD, alongside their relationships and their community. Next, I examine existing treatments and their efficacy for PTSD, specifically discussing psychotherapy treatments, and medications to help treat PTSD. Finally, I conclude with discussion of alternative therapies for PTSD, which focus on long-term treatments (e.g., yoga), but also on the concepts of exercise used as medicine (e.g., blue care, surf therapy).

In this literature review, I explore existing research results and methods and attempt to highlight gaps and critiques in an effort to identify how these fields could advance. This section also discusses how innovation in technology—through rapid advancement in hardware, software, and ubiquity of mobile devices (e.g., wearables, smart watches, sensors)—create the ability for unobtrusive collection of data (e.g., physiological biomarkers, heart data, sleep data). These technologies could yield new frontiers in data for analysis, facilitating further understanding and ushering in salubrious effects. The output of this literature review formulated the research questions used for this research study.

To identify relevant literature for this review, I conducted keyword searches on the internet and Google Scholar. Some of the search terms I used were: nature therapy, surf therapy, blue care, nature assisted therapies, PTSD, PTSD symptoms, PTSD risk-seeking behavior, PTSD treatment, self-efficacy, PTSD depression, and PTSD alternative therapy. I accessed databases such as Sage, PubMed, PSY articles, and ProQuest, and reviewed reference sections of each peer reviewed article to identify relevant articles.

Mental Health

In this section on mental health, I review how PTSD affects mental health, the causes, populations impacted (e.g., military veterans), history, and prevalence of this condition. This examination of PTSD also includes the costs of care, burdens, and financial impact and harm PTSD could inflict, such as an increased suicide rate.

To provide some context around the cost of mental health, the Substance Abuse and Mental Health Services Administration (2023) budget request for fiscal year 2023 was $10.7 billion, an increase of $4.6 billion from fiscal year 2022. This administration is the primary federal agency responsible for addressing mental and substance abuse disorders. The federal government covers some costs of treating mental health disorders (The White House, 2022c). Estimated 2019 mental health and associated spending for care equated to over 5.5% of all health spending, with the market spending $225 billion (Substance Abuse and Mental Health Services Administration, 2014). In 2020, the number grew to over $280 billion, including over $2 billion to combat the opioid epidemic, and $2 billion to fund the National Institute of Mental Health (The White House, 2022c). These numbers do not include indirect costs, such as lower workforce participation, decreased productivity, and strain on intrapersonal relationships, families, and communities.

Mental health technology startup companies pulled in a record-breaking $5.5 billion in funding in 2021, up 139% from 2020 (CB Information Services, 2022). These large investments of capital are one of the only positives in a bleak landscape as the COVID-19 global pandemic has continued to exacerbate mental health issues, with suicide rates on the rise and reports of increased substance abuse, dramatically demonstrating the need for research, focus, and improved care (Czeisler et al., 2020). These numbers are shared to place the magnitude and emphasis on the importance of this research.

Furthermore, veterans' health care is predominantly administered by the VA and faces a challenging operating environment (VA, 2021a). The following trends summarize these challenges:

- The U.S. government's fiscal situation, chiefly the size of the federal deficit and the percentage of funds that must go to service debt, constrain discretionary spending in the future and limit benefits and services available to veterans from other federal agencies and private sector organizations.
- There are ongoing efforts to reform, streamline, and downsize federal agencies, and make the federal workforce more efficient. As part of this effort, VA budget growth will plateau or even shrink after years of expansion as wars become less visible.
- There are steady increases in mandatory spending as more veterans return with increased needs, including more service-connected disabilities.
- There are escalating costs of health care, education, and other VA benefits and services.
- There are continuing increases in the incidence of traumatic brain injuries, polytrauma, PTSD, and opioid use.

This difficult environment where veterans seek care, combined with the aforementioned stigmas and barriers to receiving care and budgetary constraints, demonstrate the importance of research to further understanding of treatment modalities, potential health solutions, including reductions in PTSD, depression, and anxiety, while improving health and reducing suicide. Identifying low-cost, highly scalable solutions are of critical importance in the midst of shrinking budgets, increasing complexities and cost of care, and an increasing number of people affected, delivering a notable opportunity to further explore treatments.

PTSD

PTSD is a mental health problem individuals may develop after experiencing or witnessing a life-threatening event, such as combat, natural disaster, car accident, or sexual assault (Yehuda, 2004). Anyone can develop PTSD at any age. Several factors, many outside of a person’s control, can increase the chances of PTSD. PTSD is a widespread disorder impacting many people; the number of people affected by PTSD and the percentage of the population with PTSD continue to increase (Whitworth & Ciccolo, 2016). One particular population at elevated risk for PTSD is soldiers. Blakeley and Jansen (2013) saw a 65% increase in mental health diagnoses among active-duty personnel between 2001 and 2011. PTSD is a source of dysfunction for veterans, with the rates of treatment for veterans remaining low because dynamics of the military culture present several barriers to treatment (e.g., stigmas), which often prevent veterans with PTSD from seeking help from mental health professionals, shown to be associated with an increased risk of suicide ideation and poor adherence to exercise (Hoge et al., 2004; Radomski & Brininger, 2014; Sareen et al., 2007).

The VA reported the prevalence of PTSD among veterans has been on the rise, with veterans from Operation Iraqi Freedom and Operation Enduring Freedom receiving health care in Fiscal Year 2002 to Fiscal Year 2012 increased to 29% (VA, n.d.-c). Tanielian and Jaycox (2008) found about 20% of veterans who served in Operation Iraqi Freedom and Operation Enduring Freedom had PTSD. The number of Gulf War (i.e., Desert Storm) veterans reporting PTSD was about 12% (Kang et al., 2003). About 30% of Vietnam War veterans were estimated to have been diagnosed with PTSD (Kulka et al., 1990). The variation in numbers could be attributed to the individual's role in the war, station, location, where the war was fought, and the type of enemy they faced. Extended deployments, higher rates of survival from wounds, and exposure to multiple improvised explosive device blasts specific to the Iraq and Afghanistan wars have contributed to higher rates of PTSD in veterans from these wars (Seal et al., 2009; Tanielian & Jaycox, 2008).

Stress can exacerbate PTSD and social support can decrease it (Ozbay et al., 2007). The cost of PTSD to the individual is significant due to comorbidities, with many exhibiting symptoms years after onset, and a risk of suicide and health problems being more common in individuals with PTSD (Sharpless & Barber, 2011). The impact of PTSD extends far beyond the individual; it can strain relationships, affect families, and affect their community. The cost of PTSD to society is also significant and exceeds that of any other anxiety disorder (Marciniak et al., 2005).

Records of PTSD are found throughout history, with iterations and diagnoses of PTSD dating back in written language to the dawn of the human species, seen in Greek literature such as The Epic of Gilgamesh and by Herodotus (Crocq & Crocq, 2000). Hippocrates described soldiers who experienced frightened battle dreams. In the late 1600s, Swiss physician, Dr. Hofer, coined the term *nostalgia* to describe soldiers who suffered from despair (Bentley, 2005). Auenbrugger (1761), an Austrian physician, wrote about trauma-stricken soldiers in the book

Inventum Novum, describing soldiers as listless and solitary. After the U.S. Civil War, doctors found many soldiers had physical issues with breathing and other troubling cardiovascular symptoms, which became known as *soldiers heart* or *irritable heart* (Crocq & Crocq, 2000). During the World Wars, there was a condition called *shell shock*, and a similar description after World War II was titled *combat fatigue*. Other previous diagnoses included *gross stress reaction*. The American Psychiatry Association included the term PTSD in 1980 (Crocq & Crocq, 2000).

U.S. veterans receive care through the VA. Initially concepted by President Lincoln and signed into legislation on March 3, 1865, the VA established a network of national facilities to care for the nation's wounded Civil War soldiers (VA, 2021c). This network was the first government institution in the world created specifically for honorably discharged volunteer soldiers. The VA mission was "to care for him who shall have borne the battle, and for his widow, and his orphan" (Celebrating America's Freedoms, n.d., p. 2). The modern-day impact, cost, and burden of PTSD is significant, exhibited financially and depicted by suicide rates. The VA Fiscal Year 2018–2024 Strategic Plan described the major efforts the VA would undertake in the following 5 to 7 years to deliver tailored and desired outcomes for veterans (VA, 2018). The top additional area of focus in this plan was suicide prevention, which was the top clinical priority for the VA. Between 2005 and 2016, the veteran suicide rate increased 25.9% (Office of Mental Health and Suicide Prevention, 2018). In the 2019 fiscal year budget, President Trump proposed a $198.6 billion budget for the VA (Office of Public Affairs, 2018). This funding was an increase of $12.1 billion over 2018. Guided by Executive Order 13861 (i.e., National Roadmap to Empower Veterans and End Suicide), the VA planned to engage federal, state, tribal, faith-based, and local partners to cultivate social support networks and connect veterans to their community to foster a sense of belonging that improves quality of life for veterans. The VA also planned to coordinate with academia and nonprofit organizations to integrate research efforts and fill gaps where research is needed, leveraging data sharing to identify at-risk veterans and factors that contribute to suicide and develop and implement strategies that end veteran deaths by suicide.

As of 2019, veterans consisted of 13.5% of adult suicides in the United States but only made up 7.9% of the U.S. adult population (Cerel et al., 2019). The federal government has been working to improve access to mental health services for veterans, servicemembers, and military families through Executive Order 13625, which was issued on August 31, 2012. Among this effort, they sought to "improve data sharing between agencies and academic and industry researchers to accelerate progress and reduce redundant efforts without compromising privacy" (Administration of Barack Obama, 2012, p. 3). In addition, the National Research Action Plan—which was created by the Department of Defense, the Department of Veteran Affairs, the Department of Health and Human Services, and the Department of Education in response to Executive Order 13625—improving access to mental health services for veterans, servicemembers, and military families would include strategies to support collaborative research to address suicide prevention (Interagency Research Committee, 2013). Executive Order 13861 established PREVENTS to lead the development and implementation of a national, comprehensive roadmap to change how our nation treats mental health and understands suicide prevention (VA, 2021b).

Congress has acknowledged issues of research, treatment, access to care, and suicide prevention (Restoring Hope for Mental Health and Well-Being Act of 2022, 2022). It is for this reason alone this research study is justified, let alone cost efficiencies and scalability. Several evidence-based treatments are available; however, it is notable that only a small percentage of soldiers diagnosed with PTSD or who have been experiencing PTSD symptoms get treatment because of various reasons, such as military culture, stigma, and lack of access to mental health care (Corrigan et al., 2014; Crawford, 2016).

In this section, I discussed PTSD history, causes, prevalence, and a specific population impacted (i.e., military veterans). This examination of PTSD also included the cost, in terms of care and burden, and financial cost, exhibited through VA budgets and spending, and harm such as disproportionately large suicide rates.

PTSD Symptoms

In this section, I discuss the types of PTSD symptoms and behaviors. Specifically, I examine the VA's defined four types of symptoms, behaviors, activities, and issues exhibited, such as (a) sensation seeking and risk taking, (b) criminal behavior, (c) substance abuse from a legal perspective, and (d) the strain on intrapersonal relationships. All these issues can deeply affect a person, their relationships, and the community of people diagnosed with PTSD. According to the VA, there are four types of PTSD symptoms, but they may not be exactly the same for each individual. Each person experiences PTSD symptoms in their own way (VA, n.d.-a). The four symptoms include:

- Reliving the event (i.e., reexperiencing symptoms). Memories of the traumatic event can come back at any time. Individuals may feel the same fear and horror they did when the event took place. They may have nightmares. They may feel like they are going through the event again, which is called a *flashback*. They may see, hear, or smell something that causes them to relive the event, which is called a *trigger*. Encountering news reports, seeing an accident, or hearing a car backfire are examples of triggers.

- Avoiding situations that remind them of the event. They may try to avoid situations or people who trigger memories of the traumatic event. They may even avoid talking or thinking about the event. They may avoid crowds because they feel dangerous. They may avoid driving if they were in a car accident or if their military convoy was bombed. If they were in an earthquake, they may avoid watching movies about earthquakes. They may keep busy or avoid seeking help because it keeps them from having to think or talk about the event.
- Negative changes in beliefs and feelings. The way individuals think about themselves, and others changes because of the trauma. This symptom has many aspects. They may not have positive or loving feelings toward other people and may stay away from relationships. They may forget about parts of the traumatic event or not be able to talk about them; they may think the world is completely dangerous, and no one can be trusted (National Center for PTSD, 2010).
- Feeling keyed up (i.e., hyperarousal). Individuals may be jittery, or always alert and on the lookout for danger. They might suddenly become angry or irritable, which is known as *hyperarousal*. They may have a challenging time sleeping, trouble concentrating, or may be startled by a loud noise or surprise. They might want to have their back to a wall in a restaurant or waiting room.

PTSD Behaviors

Some of the behaviors associated with PTSD include: (a) sensation seeking and risk taking, (b) criminal behavior, and (c) the strain on intrapersonal relationships. Previous research has suggested people with a history of deployments and/or PTSD sometimes tend to participate in risky activities that have an intense sense of physiological and psychological arousal

(Crawford, 2016; Hauffa et al., 2011; Myrseth et al., 2012). Veterans or military servicemembers—especially servicemembers experiencing PTSD symptoms—tend to seek activities that would make them feel alive again, which is why they tend to do activities like extreme sports. Hauffa et al. (2011) analyzed the connection between PTSD and stimulation seeking among military members, using various scales, and found military members with PTSD had increased stimulation seeking scores. Additional researchers found former military members who tested positive for PTSD engaged more frequently in risky behaviors and had an increased urge to participate in impulsive activities (Brymer & Schweitzer, 2013; James et al., 2014). Similarly, Killgore et al. (2008) found U.S. soldiers tend to participate in reckless driving and increased alcohol use once home from deployment. Exposure to violent combat, human trauma, and direct responsibility for taking the life of another person might alter an individual's perceived threshold of invincibility and slightly increase the propensity to engage in risky behavior on returning home after wartime deployment.

Criminal behavior exhibited by former servicemembers who served in Iraq and/or Afghanistan has become an increasingly significant problem (Denning et al., 2014). Sherman et al. (2014) linked PTSD to increased criminal acts. Similarly, Elbogen et al. (2012) found some subsets of veterans with PTSD may be at increased risk of criminal arrest. Tsai et al. (2013) used healthcare reentry data to determine Operation Enduring Freedom veterans had lower rates of incarceration; however, veterans who were incarcerated had higher rates of PTSD. Taylor et al. (2020) conducted a systematic review and meta-analysis, finding veterans with PTSD had higher odds of criminal justice involvement and arrests for violent offenses. In summary, there are a growing number of veterans diagnosed with PTSD who have been associated with doing criminal activities (Crawford, 2016).

Studies have revealed PTSD contributes significantly to family issues and poor relationship quality (Oman & Bormann, 2015). Longitudinal research has suggested the fastest rising concern among these servicemembers is their interpersonal relationship problems (Milliken et al., 2007). What veterans do, think, and feel directly impacts people around them (Galovski & Lyons, 2004). Loved ones are often forced to deal with withdrawal, jealousy, verbal abuse, anger, and destructiveness; therefore, routine daily activities, such as hanging out with friends or taking part in school parties or kid's programs, are difficult (Galovski & Lyons, 2004; Solomon et al., 1993). The situations and stressors described above when combined with PTSD can cause a heightened state of physiological arousal that can add tension and stress or fear of provoking angry outbursts at partners and children, increased psychological and physical aggression toward partners, and poor relationship adjustment (Maloney, 1988; Owens et al., 2014). Ray and Vanstone (2009) conducted an analysis of PTSD's influence on former military families and their relationships. The major theme from that study was participants experienced emotional numbing and anger, which had a negative impact on the family relationships and emotional withdrawal of the participant from family support.

PTSD Summary

In this section, I reviewed the mental health diagnosis of PTSD through history, causes, populations impacted (i.e., military veterans), and the prevalence of occurrence. This examination of PTSD included the cost in terms of care and burden, financial cost, and harms (e.g., increased suicide rate). This review also included a discussion on PTSD symptoms, specifically the four symptoms recognized by the VA, and associated behaviors. These symptoms include (a) reliving the event, (b) avoidance, (c) negativity, and (d) hyperarousal. Finally, I examined some of the issues exhibited, such as (a) sensation seeking and risk taking,

(b) criminal behavior, and (c) the strain on intrapersonal relationships. These issues can deeply affect the person diagnosed with PTSD, their relationships, and their community.

Existing Treatments and Efficacy

In this section, I highlight existing treatments and efficacy, including (a) psychotherapy, (b) medication, and (c) alternative therapies. Specifically, I examine psychotherapy treatments in use by the VA such as cognitive processing therapy, prolonged exposure, and eye movement desensitization and reprocessing, including the effectiveness of these treatments. For medications, I identify some prescription drugs and their ability to treat PTSD and various symptoms. I conclude with an introduction to alternative therapies, literature findings, and literature gaps and critiques. I discuss how rapid implementation ability, at scale, combined with near real-time pace of communication, is outpacing policy and legislation because technology is exponentially advancing the ability to collect, process, and analyze data (Miao et al., 2022). The rapid advancement creates an entirely new possibility in using alternative therapies to combat PTSD. Additionally, I highlight a summary of findings from this research and propose a future state of research.

Psychotherapy

According to the VA, *trauma-focused psychotherapy*, which focuses on the memory of the traumatic event or its meaning, is the most effective treatment for PTSD (VA, n.d.-a). There are several types of trauma-focused psychotherapy, including:

- Cognitive processing therapy: The patient learns skills to understand how trauma changes thoughts and feelings. Changing how they think about the trauma can change how they feel.

- Prolonged exposure: A person talks about trauma repeatedly until memories are no longer upsetting. This discussion can help them get more control over their thoughts and feelings about the trauma. They may also go to places or do things that are safe, but they have been staying away from because they remind them of the trauma.
- Eye movement desensitization and reprocessing: Involves focusing on sounds or hand movements while the patient talks about the trauma. This focus helps the brain work through the traumatic memories.

Medication

Medication is the other main type of existing treatment for PTSD. Several pharmacological approaches to the prevention of PTSD—including ketamine, cortisol, and propranolol (i.e., Inderal), a beta adrenergic antagonist (i.e., beta blocker)—have been used in research studies (Sharpless & Barber, 2011). Some specific selective serotonin reuptake inhibitors and serotonin norepinephrine reuptake inhibitors, which are used for depression, can also work for PTSD. These inhibitors include sertraline, paroxetine, fluoxetine, and venlafaxine. People can get treatment for PTSD. Some people get rid of PTSD altogether and others can make the symptoms less intense. Treatment also gives an individual the tools to manage symptoms.

Alternative Therapies

Alternative therapy includes health care that is outside of mainstream Western medicine, often called *alternative medicine* or *complementary medicine* (Lindquist et al., 2018). Practices used instead of conventional medicine are alternative and ones used in conjunction with conventional medicine are complementary. Some examples of alternative therapies include massage, acupuncture, service companion dogs (i.e., pet therapy), healing touch, and yoga. Many alternative therapies have shown promise in a number of roles, most notably as adjunct interventions, helping to reduce symptoms of PTSD, depression, and anxiety (Hollifield, 2011; Lang et al., 2012; Strauss et al., 2011).

Meditation

Given the high rates of suicide in military veterans with PTSD, along with limited success of conventional treatments with high dropout rates, the treatment of meditation is one alternative approach that warrants attention, given its relatively low cost and ability to scale. Veterans may seek this type of treatment because it is nonpharmacological and does not focus on trauma. Lang et al. (2012) examined meditation and concluded meditation has been found to decrease physiological arousal, which could also lessen the sensation-seeking and risk-taking behaviors of veterans with PTSD.

Massage Therapy

Massage therapy has demonstrated positive effects on biochemistry—such as a decrease in cortisol and an increase in serotonin and dopamine—in many studies, such as studies on depression; pain syndrome; autoimmune conditions; asthma and chronic fatigue; immune studies; HIV and brain cancer; and studies on the reduction of stress on the job, the stress of aging, and pregnancy stress (Field et al., 2005). Cortisol is the body's main stress hormone, working with certain parts of the brain to control mood, motivation, and fear (WebMD Editorial Contributors, n.d.). Cortisol plays a significant role in a number of things the body does, including boosting energy so a person can handle stress. Serotonin is the key hormone that stabilizes mood, feelings of well-being, and happiness (Rathore & Sarkar, 2021). Having too little serotonin can lead to depression. Dopamine is a type of neurotransmitter, playing a role in how an individual feels pleasure, strive, focus, and finds things interesting (Cristol, n.d.). Dopamine affects many parts of behavior and physical functions, such as: learning, motivation, heart rate, blood vessel function, kidneys, sleep, mood, and attention. Having dopamine levels too high or too low have been linked to mental issues such as schizophrenia, drug misuse and addiction, Parkinson's disease, and obesity. Applying this style of research, which is currently limited, could be beneficial to apply to other therapies and treatment modalities to further understanding.

Animal-Assisted Therapy

Another alternative therapy is animal-assisted therapy, which involves the help of an animal, most commonly a dog, during the therapy. Animal-assisted therapy is considered a successful form of alternative treatment for treating several disorders, such as autism, physical rehabilitation, and PTSD (Cavanaugh & Rademacher, 2014; O'Haire & Rodriguez, 2018). These dogs are referred to as psychiatric service dogs. Studies have shown taking care of animals or being close to animals helps to calm individuals. Results from a study examining the efficacy of service dogs as a complementary treatment for PTSD in military members and veterans revealed clinically significant reductions in PTSD symptoms, including lower depression, higher quality of life, higher social functioning, and lower absenteeism due to health (O'Haire & Rodriguez, 2018). Another similar therapy using animals is equine therapy, involving horses. This therapy has been studied on diverse populations, with overall positive benefits demonstrated for a variety of populations, such as at-risk youth, people with autism, and veterans with PTSD (Ball et al., 2002; MacLean, 2011; Srinivasan et al., 2018).

Exercise as Medicine

Exercise as medicine has attracted growing research attention exploring the impact of exercise on veterans' mental health. Some studies have also examined the role of exercise in promoting psychosocial elements of recovery among veterans with traumatic injuries and disabilities (Brittain & Green, 2012; Burke & Utley, 2013; Caddick et al., 2015b). Qualitative research has additionally highlighted the psychosocial and social components that may lead to improvements in mental health through exercise (Caddick & Smith, 2017).

Several systematic reviews have gathered evidence in support of exercise as a treatment for PTSD in the general population (Rosenbaum et al., 2015) and among veterans specifically (Caddick & Smith, 2014; Whitworth & Ciccolo, 2016). Quantitative studies have identified several mechanisms for the beneficial effects of exercise on mental health, including biochemical endorphin responses and physiological responses (e.g., sleep, cardiovascular, thermogenic; Craft & Perna, 2004; Robertson et al., 2012). Exercise has been used in the treatment and prevention of a variety of chronic conditions such as heart disease, pulmonary disease, diabetes, and obesity (Thompson et al., 2020). Other determinants of health (e.g., genetics, environment, medical care) can influence health outcomes, with the biggest factor contributing to health outcomes being individual lifestyle and behavior. Manini (2015) stated, “There is no medication treatment that can influence as many organ systems in a positive manner as can physical activity” (p. 1).

Exercise has been theorized to lead to increases in neurotransmitters (e.g., serotonin) and neurotrophins (e.g., brain-derived neurotrophic factor), alleviate neuroendocrine abnormalities (e.g., hypothalamic-pituitary-adrenal axis), and enhance perceived self-efficacy, all of which could lead to increased feelings of well-being (aan het Rot et al., 2009). Furthermore, exercise may be a viable adjunctive treatment to standard care because exercise leads to better clinical outcomes in people receiving medication plus cognitive behavioral therapy for major depressive disorder (Gourgouvelis et al., 2018; Knapen et al., 2015). Gourgouvelis et al. (2018) reported exercise leads to better clinical outcomes in people receiving medication plus cognitive behavioral therapy for major depressive disorder. Exercise therapy can improve mental and physical health in patients with major depression (Knapen et al., 2015).

Physical activity occurring in the natural environment may have an especially potent influence on mental health, providing greater benefits than physical activity alone; when engaging in physical activity outdoors, there is a greater reduction of tension, anger, and depression (Thompson Coon et al., 2011; Walter, Otis, Ray, et al., 2019). Data have indicated a greater effect on mood for activities that occur near water compared with activities not near water (Barton & Pretty, 2010). Outdoor sports and physical activity in general are associated with a range of positive health benefits, such as better cardiovascular function, reduced blood pressure, resting heart rate (RHR), and a positive influence on other health markers (Eigenschenk et al., 2019). These positive health benefits result in reduced risk for many major diseases, such as heart attack, cancer, stroke, and type 2 diabetes. Physical activity and associated improvements in physical fitness are key strategies to improving health, and there are data supporting physical activity can enhance psychological health, well-being, mental health, cognition, and health outcomes (Biddle & Mutrie, 2007; Caddick et al., 2015b; Douglas & Carless, 2010; Reed & Buck, 2009). Researchers have suggested contact with nature can replenish depleted cognitive attention (Hartig & Staats, 2006) and help cultivate general feelings of vitality and well-being (Cervinka et al., 2011; Ryan et al., 2010). One participant in a scuba diving intervention said, “Diving turns me back into a human being, I go down there, and I’ve got the freedom and I’m back to being a person” (Carin-Levy & Jones, 2007, p. 64).

Sheer physical activity could improve mental well-being and supports the merit of such a therapy (Crawford, 2016). Exercise may also be an effective intervention for reducing substance abuse (Ussher et al., 2014). Exercise is known to have a hypoalgesic effect on pain, with some randomized controlled trials finding exercise therapy to be more effective than standard care at reducing pain, disability, and improving function for individuals with chronic low back pain (van Middelkoop et al., 2011). The use of sport could help veterans specifically refashion their lives and identities as disabled individuals (Messinger, 2010). LeardMann et al. (2011) indicated higher levels of physical activity is associated with decreased odds of PTSD symptoms among U.S. servicemembers. Exercise may present a unique opportunity to reduce barriers to treatment because it can be done without supervision of a mental health professional, requiring minimal supervision at all, and is often done at or near home. Exercise is familiar to the veteran community due to physical fitness standards commonly found in military organizations. Exercise mitigates most scheduling, logistics, and cost of treatment barriers because it can be done at an individual's convenience, at little to no cost (Whitworth & Ciccolo, 2016). Exercise and physical activity have demonstrated benefit to well-being and health through regulation and calming of the nervous system, not only reducing the level of stress hormones in the system, but also replacing them with mood boosters through endorphins and anandamide, which supports the merits of such therapy (Caddick & Smith, 2014; Dietrich & McDaniel, 2004; Steinberg & Sykes, 1985).

Aerobic exercises, including jogging, swimming, cycling, walking, gardening, and dancing, may help reduce anxiety and depression (Guszkowska, 2004; Stigsdotter et al., 2010). When linked to improvements in the mental health of military veterans, aerobic exercises can also provide veterans with increased sense of motivation and increased energy as a result of their participation (Otter & Currie, 2004). These improvements in mood may be caused by an exercise-induced increase in blood circulation to the brain, by an influence on the hypothalamic–pituitary–adrenal axis, and on the physiologic reactivity to stress (Guszkowska, 2004). This physiological influence is mediated by the communication of the hypothalamic–pituitary–adrenal axis with several regions of the brain, including (a) the limbic system, which controls motivation and mood; (b) the amygdala, which generates fear in response to stress; and (c) the hippocampus, which plays an important part in memory formation, mood, and motivation. Other hypotheses to explain the beneficial effects of physical activity on mental health include distraction, self-efficacy, cognitive dissonance, and social interaction (Guszkowska, 2005; Peluso & de Andrade, 2005). Many medical entities—including the Centers for Disease Control and Prevention and the American College of Sports Medicine—recommend physical activity to the general population because it is considered an important tool for the improvement of public health and has also been found to alleviate symptoms such as low self-esteem and social withdrawal (Pate, 1995).

Nature-Based Therapy

Nature-based therapy is an alternative form of treatment that focuses on the interaction of the individual and environment to achieve positive therapeutic results (Crawford, 2016). Nature-based therapies are programs that use specially designed activities in gardens or in nature environments that are appropriate for a specific group of patients (Stigsdotter et al., 2010). Another term increasingly used in environmental policy and management is nature-based solutions, defined by the European Commission as "instruments inspired by nature and using the properties and functions of ecosystems to enhance ecosystem services and multiple health benefits" (Britton et al., 2020, p. 51). These activities offer individuals the chance to simply be in the garden or other nature environment and to experience the differently designed outdoor rooms or even the nearby wild nature to promote their recovery. Having farming, hunting, gardening, fishing, and outdoor adventure experiences can result in positive outcomes in an individual's well-being and healing (Krasny et al., 2014). Likewise, M. T. Gonzalez et al. (2009) found horticultural programs showed positive changes in their study participants.

A growing body of literature has explored how engagement with nature can assist in promoting and restoring health (Britton et al., 2020; Coombes et al., 2010; Lovell et al., 2014; Maller et al., 2006; Sandifer et al., 2015). There is value and opportunity for struggling healthcare systems seeking new and cost-effective strategies (Bragg & Atkins, 2016). Furthermore, providing evidence in the effectiveness of nature-based therapy can help practitioners design and execute programs for health promotion. Noncommunicable diseases such as obesity, diabetes, and mental illness are often attributed to sedentary lifestyles, poor diet, an aging population, and social isolation in developed nations (Bragg & Atkins, 2016). In conjunction with growing rates of suicide, these diseases have caused numerous government health organizations (e.g., Kickbusch, 2015; U.K. Mental Health Taskforce, 2016; The White House, 2022b) to call health a current crisis. Public policy has been having difficulty keeping up because this research continues to outpace policy due to overwhelming demand for research and positive early initial results of the effectiveness on engaging with nature (Britton et al., 2020).

Literature has also suggested outdoor exposure (e.g., recreational pursuits such as surfing and fishing), coupled with opportunities for social interaction with peers, may be beneficial to armed forces veterans experiencing PTSD (Bennett et al., 2017; Wheeler et al., 2020). Results of these studies indicated veterans participating in these activities saw significant decreases in symptoms of PTSD, depression, perceived stress, and functional impairment, and an increase in leisure satisfaction (Bennett et al., 2017).

There has also been growing interest and increasing research in the potential use of outdoor water environments, also called blue care or blue space, in the promotion of human health and well-being (Britton et al., 2020). Surf therapy, also called ocean therapy, would qualify as a specific type of blue space activity. Globally, there is growing interest in the therapeutic potential of nature-based interventions at a policy level (Bragg & Atkins, 2016). *Blue care* is a term referring to alternative activities serving as therapy that take place on, near, or around a natural water setting (Nichols, 2014). Britton et al. (2020) described the term *blue space interventions* as “predesigned activities or programs (typically physical) in a natural water setting, targeting individuals to manage illness, promote or restore health and/or wellbeing for that group” (p. 51). *Blue space* is sometimes still subsumed under green space in particular riparian areas because it is evident there is much overlap between blue and green spaces; however, blue spaces offer quite different outcomes and benefits that are often overlooked and remain poorly understood (Haeffner et al., 2017).

Research on blue space interventions, the use of outdoor water environments in the promotion of human health and well-being, and nature-based solutions has included studies that use modalities such as surfing, river running, kayaking, scuba diving, sail training, fly fishing, and dragon boat racing (Armitano et al., 2015; Britton et al., 2020; Caddick & Smith, 2014; Caddick et al., 2015a, 2015b; Capurso & Borsci, 2013; Carin-Levy & Jones, 2007; Cavanaugh & Rademacher, 2014; Clapham et al., 2014; Colpus & Taylor, 2014; de Matos et al., 2017; Dustin et al., 2011; Fleischmann et al., 2011; Godfrey et al., 2015; Hignett et al., 2018; Lopes, 2015; McCulloch et al., 2010; McDonough et al., 2008; Mitchell & Nielsen, 2002; Mowatt & Bennett, 2011; Parry, 2008; Rogers et al., 2014; Tardona, 2011; Vella et al., 2013; M. P. White et al., 2016). These interventions ranged in length from a single day to 6 months (Fleischman et al., 2011). Populations studied included veterans, at-risk youth, inner-city youth, people with acquired physical impairments, people with drug and alcohol addiction, cancer survivors, and people with autism. Participants included adults, youth, and young adults, and their health characteristics varied with needs ranging from the physical to cognitive to psychosocial, including health issues, mental health issues, addiction, depression, physical disease, traumatic brain injury, heart defects, and breast cancer survivors (Britton et al., 2020).

Existing research focused on blue care had prominent levels of variation in sample size, ranging from studies with as few as one participant (Fleischmann et al., 2011) to over 300 participants (McCulloch et al., 2010). Many studies did not use validated measures to assess health and well-being outcomes, and also did not clearly report outcome measures, with methods ranging from qualitative, to mixed methods, to quantitative (Britton et al., 2020). Many studies did not specify the duration of the interventions, with only two systematic reviews of the literature. Some studies called out a need for better methodological approaches sampling strategies and documented procedures, including evaluations required to advance the knowledge on the topic (Britton et al., 2020; Gascon et al., 2017). Studies focused on blue space were conducted in Europe, United States, Canada, New Zealand, and one multicountry study (Britton et al., 2020; McCulloch et al., 2010). Overall, the studies suggested blue care can have direct benefit for health, especially mental health, and psychosocial well-being (Britton et al., 2020).

Other countries have used nature-based practices for health purposes. In Japan, the practice of *shinrin yoku*, or forest bathing, is good for health and well-being (Antonelli et al., 2019). The practice can reduce stress hormone production, improve feelings of happiness, free up creativity, and reduce cortisol levels, while also lowering heart rate and blood pressure, boosting the immune system, and accelerating recovery from illness (Ideno et al., 2017; Li et al., 2016; Shosha, 2021; Wen et al., 2019). There is literature to support forest bathing as having comprehensive health benefits of exposure to nature and green environments on human systems, and a significant role in promoting human health (Hansen et al., 2017). This traditional Japanese practice of immersing oneself in nature by mindfully using all five senses has even increased levels of intracellular anti-cancer proteins in female subjects (Li et al., 2008). This activity has also been called forest medicine and forest recreation. Phytoncides (i.e., wood essential oils and antibacterial and antimicrobial substances that trees and other plants release into the air) induce human natural killer cell activity, enhancing natural killer activity in human cells when humans breathe in these substances (Li et al., 2006). In the Netherlands, people have been seeking out windy exercise for more than 100 years, known as *uitwaaien*. The word translates to outblowing, or the act of spending time in the wind, with a growing body of evidence showing people benefit from being outdoors in the presence of nature (Berman et al., 2008).

Newer sensing and monitoring devices provoke much interest in the therapy, well-being, and healthcare space, and offer a promising tool for large-scale studies. The use of sensors in wearable technology allows for monitoring, managing, and even intervening in patient healthcare management in numerous symptoms and diseases, including acute and chronic symptoms, such as diabetes, cardiovascular diseases, and treatment of epilepsy and other debilitating neurological disorders. Wearable smart sensors provide novel remote monitoring techniques that can revolutionize healthcare management and spending (Appelboom et al., 2014). To date, there have been no studies in the surf therapy space that used wearable technology for data collection. This rapidly expanding market of health technology has much to offer consumers and researchers for health, well-being, quality of life, as well as government organizations to enrich public policy and understanding.

Surf Therapy

Researchers have demonstrated a newer nature-based therapeutic program (i.e., ocean therapy) appears to provide benefits to various ailments and situations, especially promising in helping veterans cope with PTSD symptoms (Caddick et al., 2015a; Crawford, 2016; Rogers et al., 2014; Walter, Otis, Ray, et al., 2019). The International Surf Therapy Organization (2019), established in 2017, defined *surf therapy* as a method of intervention that combines surf instruction/surfing and structured individual and/or group activities to promote psychological, physical, and psychosocial well-being (as cited in Benninger et al., 2020). Experienced surfers are less prone to anxiety and depression, and surfing may result in elevated mood (Levin & Taylor, 2011; Pittsinger & Liu, 2010). Surf therapy is relatively new, with the first peer reviewed publication appearing in 2010 (i.e., Morgan, 2010). There has been an increase in surf therapy studies since 2010, but research is still limited. Early results have indicated positive benefits for a handful of participants, but varying methods and populations to date have kept generalizability low (Crawford, 2016; Hignett et al., 2018; Marshall et al., 2019; Rogers et al., 2014).

The aim of ocean therapy is to reduce PTSD symptoms through a supportive group program that primarily uses surfing as the treatment modality and focuses on promulgating camaraderie among other veterans with PTSD (Rogers et al., 2014). There have been significant findings in neuroscience that involve being in, on, or around water (Nichols, 2014), which is thought to be effective for many reasons. The camaraderie is fulfilling because the soldiers experience a sense of companionship; additionally, the activity keeps them in the present, which decreases ruminating (Crawford, 2016).

Surfing requires mental focus and physical strength, which can reduce stress, reduce anxiety, and improve sleep (Guszkowska, 2004; Sharma et al., 2006). Innovative technology has shed light on how the brain reacts to being immersed in the ocean environment, with large amounts of dopamine being released as a result of the sensations of riding waves (Nichols, 2014). Brain imaging indicates proximity to water floods the brain with feel-good hormones such as dopamine and oxytocin. Levels of the stress hormone cortisol actually drop (Nichols, 2014). Participants have reported being present and fully immersed during ocean therapy, which is an activity that strongly resembles explanations of flow state, defined as “the mental state in which a person performing some activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity” (Csikszentmihalyi & Csikszentmihalyi, 1990, p. i). Csikszentmihalyi and Csikszentmihalyi (1990) suggested flow makes lives happier and more successful through positive affect and better performance.

Surf therapy emerged all over the world throughout the 2010s. Although there have been various programs in places all over the world, with many different targeted groups to benefit, there has been limited research and even more limited evidence on the topic (Crawford, 2016; Rogers et al., 2014; Walter, Otis, Ray, et al., 2019). Widely varying methods across studies appear to support surf therapy with a range of perceived benefits to participants for physical, psychosocial, and psychological health, further strengthening the case for additional research and need to validate evidence-based outcomes. At the core of most surf therapy programs, the programming includes the opportunity for participants to engage in the challenge of surfing in a socially supportive group. This setting typically includes a social connectedness to the fellow surfers, and a sense of accomplishment, which is a key component. As a result of the experience (e.g., the communal aspect, social bonding), many participants experience respite. More research is needed to examine if there are similar experiences of flow state, similar to respite, where an individual becomes fully immersed in the activity, and if they do it for intrinsic reasons, which is doing it for the sake of doing it. Past research and programs on surf therapy have included various disciplines such as occupational therapy, physical therapy, and psychology, conducted through clinical lenses, health promotion perspectives, and therapy (Crawford, 2016; Hignett et al., 2018; Rogers et al., 2014; Walter, Otis, Ray, et al., 2019).

Surf therapy can be used as a standalone intervention and augment to other approaches (e.g., traditional psychotherapy and medication management; Benninger et al., 2020). Unlike traditional treatments that often use a symptom reduction approach through talk therapy and/or medication, surf therapy programs use the physical activity of surfing as an anchor to the healing process. Many programs include additional components to the surfing instruction, such as individual mentoring, social skills development, psychoeducation, and group discussions to promote healing, strength, resilience, and personal growth in an inclusive social environment.

The first peer reviewed publication on this topic was Morgan (2010). Furthermore, a systematic literature review of randomized control trials on sports for PTSD the same year concluded no previous literature on this topic existed (Lawrence et al., 2010). Morgan's study, in partnership with the Sunset Surfers, was a pilot school holiday program aimed at building resilience in children from disadvantaged backgrounds in an inner-city Sydney, Australia, neighborhood through the provision of surfing instruction. Qualitative evaluation showed participants experienced positive effects associated with the challenging activity of learning to surf, allowing for reframing of children's negative beliefs about challenge (Morgan, 2010). Other qualitative studies also showed positive results, suggesting surfing facilitated a sense of respite from PTSD, and could promote well-being among combat veterans (Caddick et al., 2015b). Rogers et al. (2014) conducted a study with military veterans in Southern California and investigated a sports-oriented occupational therapy intervention using surf to support veterans with symptoms of PTSD in their transition to civilian life. The aim of this feasibility study investigation was to evaluate the intervention for attendance rates and retention. The results of this small, uncontrolled study suggest a sports-oriented occupational therapy intervention has potential as a feasible adjunct intervention for veterans seeking mental health treatment for symptoms of PTSD (Rogers et al., 2014).

More recent studies have examined surf therapy quantitatively using surveys and scales, collecting data across various population groups. These population groups have included at-risk youth (de Matos et al., 2017), youth with disabilities (Armitano et al., 2015; Clapham et al., 2014; Lopes, 2015; Lopes et al., 2018), youth with autism spectrum disorder (Cavanaugh & Rademacher, 2014; Mueller, 2017), youth in need of social and emotional support (Britton et al., 2020; Colpus & Taylor, 2014; Godfrey et al., 2015; Hignett et al., 2018; Morgan, 2010; Snelling, 2015), and active-duty and veteran servicemembers (Caddick & Smith, 2014; Caddick et al., 2015a, 2015b; Crawford, 2016; Fleischmann et al., 2011; Walter, Otis, Ray, et al., 2019; Walter et al., 2020). Hignett et al. (2018) specifically found a reduction in RHR due to surf therapy. This current study built on Hignett et al.'s findings by collecting physiological biomarkers for review and comparison to other study data. There has even been a study focused on body image in cancer patients (Rosenberg et al., 2014), where participants reported increased feelings of positive body image, self-esteem, and self-compassion following the conclusion of their engagement in surfing.

Marshall et al. (2020) called out the empowering process of surf therapy, where programs provide participants with the opportunity to take on the challenge of learning to surf at their own pace and to experience surfing in a nonjudgmental and socially supportive group. Other surf therapy programs exist all over the world, including in Australia (Morgan, 2010), New Zealand

(Wheaton et al., 2017), Portugal (de Matos et al., 2017), the United Kingdom (Caddick & Smith, 2014; Caddick et al., 2015a; Colpus & Taylor, 2014; Godfrey et al., 2015; Hignett et al., 2018; Marshall et al., 2019), and the United States (Armitano et al., 2015; Cavanaugh & Rademacher, 2014; Clapham et al., 2014; Crawford, 2016; Fleischmann et al., 2011; Harris, 2015; Moore et al., 2018; Mueller, 2017; Rogers et al., 2014; Rosenberg et al., 2014; Walter, Otis, Glassman, et al., 2019; Walter, Otis, Ray, et al., 2019). These surf therapy programs have focused on several different demographics and ages, using various methods, durations, and metrics to gauge effectiveness. The growth in number of studies and diversity of population and geographies is positive; however, the varying methods still leaves the need for additional research, specifically on evidence-based outcomes using standardized measures (Crawford, 2016; Walter et al., 2020). All studies aimed to provide evidence of positive changes in well-being through surfing (Benninger et al., 2020; Caddick et al., 2015b).

The U.S. Navy embarked on a $1 million research project to determine whether surfing had therapeutic value, especially for military personnel with PTSD, depression, or sleep problems (ClinicalTrials.gov, 2021). Walter, Otis, Glassman, et al. (2019), in conjunction with the Naval Health Research Center located at the Naval Medical Center San Diego, have led the aforementioned randomized controlled trial with the Injured Wellness Program, comparing surf and hike therapy for active duty servicemembers with major depressive disorder. Walter et al. conducted research on surf therapy in the military community for several years and investigated the treatment of PTSD and conditions that commonly cooccur with PTSD, such as major depressive disorder and traumatic brain injury. Walter et al. explored evidence-based treatments for PTSD and cooccurring conditions, and complementary and alternative approaches, while also working as investigators on several research trials funded by the U.S. Department of Defense.

Walter, Otis, Glassman, et al.'s (2019) initial research suggests surfing can lead to a decrease in insomnia and feelings of anxiety, and a decline in an overall negative view of life and other symptoms of depression. At the time of the study, Walter et al. were leading clinical trial NCT03302611, which was a trial of surf and hike therapy for major depressive disorder (U.S. National Library of Medicine, n.d.). This prospective longitudinal randomized controlled trial would enroll up to 86 active-duty servicemembers with major depressive disorder who are seeking surf or hike therapy as part of their standard medical care, randomly assigned over 6 weeks.

Methods in the Literature

In this chapter, the methodological discussion begins with a review of the study measures and designs used in existing relevant surf therapy literature and research. This section includes a list of the various quantitative tools I used, qualitative methods, and discusses where research has been conducted geographically, with what populations, and includes the functions and purpose of the interventions. The section highlights gaps, limitations, and critiques, concluding with a summary of literature findings and future research that could further enhance the field.

Study Measures and Design

This section focuses on the study measures and designs that have been used in previous studies and research. At the time of this study, there was limited research on surf therapy and even scarcer empirical evidence, combined with a lack of variability in the methods, measurements, and instruments used (Benninger et al., 2020). Benninger et al. (2020) conducted a search of peer-reviewed journals, books/chapters, theses, and dissertations on surf therapy, which yielded 29 results. Walter et al. (2020) authored a special issue of the *Global Journal of Community Psychology Practice* that included an additional eight studies. The pretest–posttest was the most used method and measurement in the respective studies. The observational pretest–posttest design is an accepted practice among community-based organizations and serves as a means of reporting to funders; however, it does not offer sufficient rigor to clearly provide causal inference for changes in outcomes, which is critical to program sustainability (Walter et al., 2020). Many of the studies used experimental design, which makes it difficult to fully evaluate the impact. Most of the studies do use standardized measures; however, there is significant variability in the measures used and inconsistency in the way the same constructs (e.g., trauma and physical fitness) were measured across studies (Benninger et al., 2020). Walter et al. (2020) used a prospective, longitudinal study design. Other methods in surf therapy studies included qualitative clinical interviews and dialogical narrative analysis and quantitative self-report survey assessment tools to measure impact (Caddick et al., 2015a; Crawford, 2016; Rogers et al., 2014; Walter, Otis, Glassman, et al., 2019).

Further deviating in research designs, other researchers used participatory community research (Britton et al., 2020), narrative design (Caddick & Smith, 2014; Caddick et al., 2015a, 2015b), case study design (Cavanaugh & Rademacher, 2014; Moore et al., 2018; Mueller, 2017), evaluation study design (Gomes et al., 2020), and qualitative evaluation design (Morgan, 2010). Other qualitative data collection methods included semistructured life history interviews, focus group discussions, participant observations, field notes, and program data. Caddick and Smith (2014) used participant observation, observing veterans participate in the daily activities of twice weekly surf camps, and during 3 residential weeks in which Caddick and Smith actively immersed themselves in the group environment and joined in their activities. Following the period of observation, Caddick and Smith used fieldnotes to document the findings, resulting in 90 hours of observational data.

Prior research studies on this topic have used a wide array of tools, self-report surveys, and questionnaires, including:

- Diagnostic and Statistical Manual of Mental Disorders V (DSM-5)
- General Anxiety Disorder Scale (GAD-7)
- General Self-Efficacy Assessment
- Beck's Depression Inventory
- Patient Health Questionnaire (PHQ-8, PHQ-2, PHQ-9)
- Stirling Children's Wellbeing Scale
- Warwick-Edinburgh Mental Wellbeing Scale
- Rosenberg Self-Esteem Scale
- Strengths and Difficulties Questionnaire
- Positive and Negative Affect Schedule
- Children's Hope Scale
- Brockport Physical Fitness Test
- Insomnia Severity Index
- Borg Rating of Perceived Exertion Scale
- Athletic Identity Measurement Scale
- International Physical Activity Questionnaire—Short Form
- Physiological measures (e.g., heart rate, blood pressure)
- Fitbit physiological measures

The aforementioned list contains the methods and tools used across the limited research on surf therapy. Scarce empirical literature varies widely; thus, there is an opportunity to continue and expand research, focusing future research for greater impact and understanding (Armitano et al., 2015; Britton et al., 2020; Crawford, 2016; Godfrey et al., 2015; Hignett et al., 2018).

Populations

Surf therapy research sample sizes ranged from one participant to 492 participants. Crawford (2016), who worked with Operation Surf for a research study, contacted 113 veterans to participate in their study, with 95 veterans completing the surveys at three separate times. Walter, Otis, Glassman, et al.'s (2019) clinical trial planned to enroll up to 86 participants in a U.S. Navy randomized controlled trial.

Research from the 2010s produced several studies examining impact and benefits of ocean therapy with several different demographics, including youth with disabilities and mental health conditions (Armitano et al., 2015; Clapham et al., 2014; Lopes, 2015; Lopes et al., 2018; Marshall et al., 2019), youth in need of emotional support (Britton et al., 2020; Godfrey et al., 2015; Hignett et al., 2018; Morgan, 2010; Snelling, 2016), children and youth with autism spectrum disorder (Mueller, 2017), institutionalized youth (de Matos et al., 2017), adults with addiction (Harris, 2015), the active-duty military community (Walter, Otis, Glassman, et al., 2019; Walter, Otis, Ray, et al., 2019), and veterans (Caddick & Smith, 2014; Caddick et al., 2015b; Crawford, 2016; Fleischmann et al., 2011; Rogers et al., 2014).

Program Information

Research has indicated surf therapy appears to have a positive impact on participants, although methods vary greatly, with many studies having used subjective metrics. These early results are promising enough to justify further investigation. For this review of literature and research study, I focus on the military veteran community through a few key research studies conducted in this space (Caddick & Smith, 2014; Crawford, 2016; Rogers et al., 2014; Walter, Otis, Glassman, et al., 2019; Walter, Otis, Ray, et al., 2019). The studies Britton et al. (2020) included in the review were highly heterogenous and varied in disciplinary origin, with different approaches to study design and use of methods. These disparate methods, designs, and approaches further justified the need for additional and focused research in the surf therapy space.

Focus areas of the examined literature included physical strength and fitness, general health and well-being, psychological and mental health, and psychosocial well-being (Benninger et al., 2020). Durations of the studies, participants' activities and involvement, and even weather conditions varied widely, including an outstanding issue of unconfirmed line of proper dosage, which is discussed with critiques later in this chapter. Most programs lasted between 5 to 8 weeks with one session per week, although some programs were as short as 1 day and a few spanning 6 months. One study (i.e., Richie et al., 2015) stretched out over 1 year.

Some of the existing studies this study will attempt to build upon specifically using components include Crawford (2016), Rogers et al. (2014), and Walter, Otis, Glassman, et al. (2019). Walter, Otis, Glassman, et al. conducted a 6-week program as part of standard medical treatment (i.e., scheduled medical appointment) for active-duty servicemembers seeking care. The program did not include a structured psychotherapy or therapy component; rather, engagement in the activity in the natural environment and social interaction and support were considered the therapeutic elements (Caddick et al., 2015b; Walter, Otis, Glassman, et al., 2019). Walter, Otis, Glassman, et al. (2019) used clinical interviews and self-report assessments before and after each program, and 3 months after the program's conclusion, to evaluate the effects of program participation on patient outcome. Self-report assessments were also completed immediately before and after each activity session. Sessions for this program occurred 1 day per week for 6 consecutive weeks. Rogers et al.'s (2014) program comprised five 4-hour sessions occurring weekly for 5 consecutive weeks, and was one of the first to use surfing as a potential treatment modality.

Function and Purpose of Interventions

Surf therapy studies I reviewed did have homogeneity in their aim to provide evidence of positive changes in veteran well-being. Several of the surf therapy programs aimed to improve outcomes related to self-concept, self-efficacy, and self-esteem (Cavanaugh & Rademacher, 2014; Crawford, 2016; Fleischmann et al., 2011; Godfrey et al., 2015; Rosenberg et al., 2014). Many of the studies focused on blue care, but intervention aims and objectives in many of these studies were not clearly stated (Britton et al., 2020). Several studies emphasized a therapeutic approach, such as participation in meaningful activities in the natural environment as part of the therapeutic process and a desired outcome (Rogers et al., 2014). In one qualitative study, Caddick et al. (2015b) described surfing as a vehicle for pursuing pleasure and escaping pain rather than for loftier notions of psychological growth and development. Godfrey et al. (2015) stated surfing provides a chance to forget problems rather than focus on them. Berger and Tiry (2012) highlighted the potential for creative processes to help adults better engage with nature and how nature can spark greater creativity. Several studies have captured the physical, psychological, and social benefits of combining physical activity and being in nature; however, there is need for more evidence that supports the potentially unique benefits of using the sport of surfing as a key element of a novel therapeutic intervention (Eigenschenk et al., 2019).

Gaps in Ocean Surf Therapy Literature

Numerous studies have used self-report surveys because they are easy to distribute, low cost, and easy to scale; however, they are also subject to biases due to variations in question interpretation, socially desirable responses, and subjectivity (Walter, Otis, Glassman, et al., 2019). Funding and research expertise continue to be difficult roadblocks for surf therapy programs because research capacity is limited, preventing more rigorous research and limiting funding. Physiological biomarker data were extremely limited in research to date, with heart rate data used in Hignett et al.'s (2018) study out of the United Kingdom focusing only on at-risk youth. Walter, Otis, Glassman, et al. (2019) captured physiological data but did not conduct analyses. Walter et al.'s (2020) clinical trial that was underway at the time of this current study opted to use a Google Fitbit to capture physiological data for the randomized controlled group participating in the hiking therapy portion of the study but did not choose to use a waterproof wearable to include in the surfing component of the study.

The 2010s witnessed a rapid surge in hardware and software technological ability, fueling interest in new sensing and monitoring devices for well-being and healthcare. For example, Google acquired Fitbit for $2.1 billion in 2021, promoting the deal as a way to help spur innovation in wearables and demonstrating strong support and interest (Crunchbase, n.d.).

The use of wireless, wearable, and even implantable sensors allows for monitoring and intervention, permitting the management of patients with acute and chronic symptoms, including diabetes, cardiovascular diseases, treatment of epilepsy, and other debilitating neurological disorders (Yang, 2014). Using this technology—in the form of a Whoop band, which allows for unobtrusive monitoring of fitness, health, sleep, and recovery data—can measure such physiological biomarkers such as heart rate variability (HRV), RHR, and sleep. Establishing processes and best practices around data collection using these devices could help to demonstrate feasibility and encourage more of this type of research in many different sectors. This current research resulted in new data sets, allowing for more robust analysis and yielding data-driven insights to further advance the field.

Because wearable technology is comprised of new hardware and software components, data collected through these tools has been scarce; there has not been considerable time to conduct research. Early evidence has indicated consumer-grade sleep trackers have promise as tools for large-scale sleep studies (de Zambotti et al., 2019; Pesonen & Kuula, 2018). Limited research has been conducted to date examining wearable technology.

Devices may be a helpful method of assessing sleep due to their objectivity, availability to the general population, and capacity to monitor sleep continuously, but validation is required for the use in clinical practice (Moreno-Pino et al., 2019). Technology hardware varies among brands, with some using accelerometers and some using polysomnography. Surfing is a physically and mentally demanding sport, which could improve sleep but research to date has been scarce; wearable technology and this research study could help by generating new data sets and increasing awareness of this type of field research feasibility.

Qualitative Gaps

In reviewing existing published qualitative research, I found a few gaps in the literature to date. Caddick and Smith (2017) discussed the approach of exercise as medicine to the veteran community, and the potential benefit and hamper that can come through offering treatment under this approach. On one hand, having this treatment framed with a medicalized understanding of mental health and treatment could confer a legitimacy that exercise has traditionally lacked (Caddick & Smith, 2014; Faulkner & Biddle, 2001; Smith & Perrier, 2014). This research could help attract funding in support of this work, having the clinical language to articulate the benefits and funding requirements (Caddick & Smith, 2017). This research could be a strong political strategy to argue for a share of the resources for veterans' mental health treatment. On the other hand, this strategy does provide a potential drawback. An attempt to legitimize the approach could undermine its appeal in the eyes of veterans themselves, for whom a nonmedical approach may play a key role in challenging the stigma that can be associated with mental health treatment (Caddick & Smith, 2017; Caddick et al., 2015b; Whitworth & Ciccolo, 2016).

One way to understand the instrumental rationality of promoting exercise as medicine for veterans would be to conduct further qualitative research with veterans to explore whether the promotion and marketing would make them more or less likely to engage in the activity, and why. More diverse qualitative methodologies (e.g., ethnographies and case studies) might also be used to further understanding of the physical culture of veteran's exercise participation. Disentangling the various aspects (e.g., individual versus group based, competitive versus noncompetitive, natural versus built environments) of exercise-based approaches may also be important for supporting mental health (Caddick & Smith, 2014). Much of the qualitative research has focused on the feelings of respite experienced by veterans through surfing, which shares many similarities to flow state. Previous flow state research has been connected to infusions of neurochemicals, which can enhance pleasure, improve physical and mental performance, and sharpen creativity (Csikszentmihalyi & Csikszentmihalyi, 1990). To date, there is no research examining these infusions of neurochemicals and the impact they may facilitate on various elements, namely PTSD symptoms, as related to surfing.

Critiques

Although surf therapy shows promise in early research, there are a myriad of critiques and limitations in the literature and studies to date. Despite promising early research, most studies have used experimental design, which makes it difficult to fully evaluate the impact of surf therapy (Walter et al., 2020). Walter, Otis, Glassman, et al. (2019) explained the literature on surf therapy lacked methodological rigor, which was a guiding reason in building their randomized controlled trial. They wanted to address design limitations on incorporation of a comparison group, use of a longitudinal design, and inclusion of multiple methods of data collection. The randomized controlled trial underway at the time of this current study was the first and only in the surf therapy research space to date.

The field could benefit from additional research conducted with scientific rigor. Surf therapy has a need for comparison groups, control groups, common metrics, and assessment tools, and will need additional understanding of dosage and duration (Walter et al., 2020). Operation Surf conducts weeklong programs and a 6-month program, whereas vulnerable youth populations have programs ranging from 1 day to 3 years (Crawford, 2016; Gomes et al., 2020; Walter et al., 2020). Dosage would need to be optimized for session frequency, duration, and program length because determining these lengths for optimal functional outcome is vitally important (Walter et al., 2020). This optimization would not only allow for greater benefit for participants, but it would also improve efficient use of resources. Surf therapy studies include similar components, however, the additional program activities apart from surfing, which are included in the programming, further cloud the perceived results and make quantifying the impact more difficult. For example, the Operation Surf weeklong surf therapy event includes optional yoga on the beach in the morning prior to the first surf lesson of the day. Surf instructor preparation and methodology of instruction vary across different programs, which further complicates understanding results and attributing causal inference; ocean environment, ocean conditions, and equipment could even affect program outcomes (Marshall et al., 2019). Program evaluation can serve as an initial step but does not shed light on whether reported changes are due to surf therapy, time, concurrent interventions, or other factors (Walter et al., 2020).

Although there are many psychological benefits demonstrated through the research on surf therapy, more research is needed to understand and design programs for optimal efficiency, cost, and scale. A limitation existed in this current study around privacy and healthcare data due to the Health Insurance Portability and Accountability Act of 1996, which limits sensitive patient health information, because many participants were concurrently taking medication or involved in other forms of therapy at the time of intervention, which could impact results (Walter et al., 2020). This limitation further makes the impact of surf therapy difficult to isolate and quantify. Additionally, very few surf therapy studies have acknowledged the use of other interventions by participants nor report these data, which are necessary for understanding the independent effects of surf therapy (Walter et al., 2020).

Operation Surf runs dry events asking participants and staff to please not consume alcohol or other substances. Speaking to one veteran from an event of theirs openly talked about how she did not bring or use cannabis—which she used as treatment in the state of California where it was legal by state guidelines—to honor the requested dry policy. Due to not taking her cannabis, she filled her anxiety medication from the pharmacy, which she usually does not take when using cannabis, but felt she had to cope. This example is not necessarily a critique of surf therapy but demonstrates the ancillary complexities of isolating and quantifying impact. Existing surf therapy research has attempted to understand impact through program evaluation, but what remains unknown is if outcomes on reported changes are due to surf therapy, time, or concurrent interventions (Walter et al., 2020). Surf therapy has been executed and researched as adjunct intervention and standalone treatments; rigorous research should attempt to understand how the benefits differ and if the various program execution styles create varying success for optimal delivery.

As discussed previously, there is an extensive list of different surveys and tools used in the existing body of research; establishing common assessment instruments is crucial because it allows for comparison between studies, populations, and outcomes, which ultimately serves to build a global research base for surf therapy (Walter et al., 2020). An overreliance on self-report data was a limitation of prior research on surf therapy outcomes (Walter, Otis, Glassman, et al., 2019). Future research studies should analyze outcome data by sessions attended and the duration of sessions attended so optimal dosage can be ascertained and frequently assess outcomes during surf therapy programs and after programs have been completed so the duration of effects can be established (Walter et al., 2020).

Wearable technology that gathers physiological data is a new field with scarce rigorous research. The technology is improving, and data captured via these wearable devices are rapidly expanding, but it will take time to conduct and analyze research studies. Berryhill et al. (2020) produced a sleep study using Whoop bands as the wearable technology with findings indicating wearables can improve sleep quality and accurately measure sleep and cardiorespiratory variables in healthy people. The Whoop band data were as good as the electrocardiogram, the gold standard instruments in the field, the electrocardiogram, which is used to check for heart conditions, and inductance plethysmography during polysomnography, a comprehensive test used to diagnose sleep disorders (Berryhill et al., 2020). Two critiques of Berryhill et al.'s research was the study was funded by a grant from Whoop, and the analysis was performed on only 1 night when using the wearables.

Capodilupo and Miller (2021), Whoop's lead research scientists, examined the impacts of the COVID-19 global pandemic, using the data from their subscriber base. Capodilupo and Miller mentioned in the critiques the study had not been peer reviewed and most likely had an implicit bias because they were employed by the company at the time of the study. Their results may not be generalizable and may not be representative of the global changes in behavior because data were gathered only from the U.S. This example demonstrates the limited research conducted in the field to date.

Altini and Kinnunen (2021) performed a comprehensive analysis using a multisensory sleep tracker (i.e., Oura Ring) compared against polysomnography to measure sleep and sleep stages. The researchers found the rings have the potential for detecting outcomes beyond binary sleep–wake stages using sources of information in addition to motion data. These initial results could be viewed as promising, but future development and validation are needed. This Oura Ring study suggests high accuracy sleep detection and sleep staging can be accomplished; however, one of the authors was employed by Oura Health, and the other author was an advisor to Oura Health, which could lead to potential bias.

Studies on Fitbit wearable devices, a competitor to Whoop bands and Oura Rings, showed an acceptable sensitivity but poor specificity when testing reliability, leading researchers to suggest consumer sleep trackers still have insufficient accuracy for clinical settings (Moreno-Pino et al., 2019). By solving technical issues and optimizing clinically oriented features, these devices could become apt for use in clinical practice in the near future. Walter, Otis, Glassman, et al. (2019) observed one type of Fitbit device (i.e., Fitbit Charge 2) showed mixed results on heart rate accuracy, which was also found in other literature to date (Benedetto et al., 2018; Salazar et al., 2017; Thomson et al., 2019).

As this list of limitations demonstrates, surf therapy shows promise, but further research is justified. More research with sound study designs, using standardized metrics, and conducted with scientific rigor would help to understand the impact of surf therapy. Isolating and quantifying impact remains difficult even when adding standardization and scientific analysis. These critiques further guided the formulation of research questions and this research study as a result of this literature review. A mixed methods approach with qualitative analysis, in conjunction with additional quantitative data using common metrics and assessments, could produce a more robust analysis, adding new physiological data to further understanding.

Summary of Literature Findings

The following section highlights the findings from conducting a literature review on the field of surf therapy as a response to mental health issues, specifically PTSD. The findings are organized into sections that focus on psychological, physiological, qualitative, and psychosocial findings, concluding with recommendations for future research that could further the field of study.

Psychological

Early surf therapy research conducted by Rogers et al. (2014) led researchers to believe surf therapy has potential as a feasible adjunct intervention for veterans seeking mental health treatment for symptoms of PTSD. Crawford (2016) built upon these initial results, publishing a study shortly thereafter with results that showed surf therapy led to a 36% decrease in PTSD symptoms, 47% decrease in depression, and a 68% increase in self-efficacy for military veterans with PTSD. Additionally, beneficial effects of surf therapy included higher self-esteem, strengthened coping skills, and lower rates of suicide. Active-duty military servicemembers participated in a study with Walter, Otis, Glassman, et al. (2019) at the Naval Health Research

Center located at the Naval Medical Center in San Diego, California. Data from the program evaluation phase of the surf therapy study, which used a single group design, demonstrated significant improvements in psychological symptoms, including increases in positive affect; decreases in negative emotions; and reduced symptoms of depression, anxiety, and PTSD. However, 75% of participants were receiving some other type of treatment (e.g., psychotherapy, medication management, physical therapy) in addition to surf therapy. Another active-duty military servicemember case study found surf therapy had the ability to provide an alternative form of pain management (Fleischmann et al., 2011). Fleischmann et al. (2011) found people had a dramatic and sustained reduction in narcotic opioid use after a 6-month surfing intervention.

Surf therapy interventions for challenge-averse populations—such as foster youth, youth at risk of isolation, youth with a history of abuse and neglect, and youth exposed to violence—can provide a manageable challenge in a fun and supportive context (Benninger et al., 2020). The results from several studies indicated surf therapy can lead to: (a) improvements in physical fitness, self-confidence, social development, behavior, and sleep; (b) reduced levels of anxiety; (c) increased self-concept, emotional regulation, and social competencies; (d) reengaging students with school; and (e) decreased behavioral problems (Armitano et al., 2015; Benninger et al., 2020; Cavanaugh & Rademacher, 2014; Clapham et al., 2014; Lopes, 2015; Moore et al., 2018; Mueller, 2017). Strength of evidence varied across studies, which could have been due to a variety of factors such as program delivery, incomplete attendance, or even environmental conditions (e.g., ocean swell conditions, weather).

Some studies mentioned participants experience psychological empowerment through the notion of play by engaging in the physical activity of surfing in an unpredictable but fun ocean environment where they must focus attention on each moment while learning to ride a wave

(Gomes et al., 2020; Marshall et al., 2020; Walter et al., 2020). The focus of mind and body required by the ocean environment simultaneously brings respite, a break from trauma symptoms, or from being stigmatized due to being a part of a disenfranchised group. In addition to the required focus, social connectedness to fellow surfers and a sense of accomplishment from the act of surfing, which is transferrable to other activities, can enhance respite (Marshall et al., 2020).

Nordh et al. (2009) examined the effects of nature-based therapy intervention program in forests for individuals suffering from stress-related mental disorders, finding participants experienced improvements in cognitive and physical functioning and reductions in stress symptoms. However, the results of this study revealed participants had a reduced quality of life, which was explained as being due to participants' disappointment that there would be no continuation of the program after the study. Caddick and Smith (2014) shared a similar concern, noting some veterans in their study reported experiencing adverse emotional effects after the surf study had finished.

Other impacts noted in the research on psychological well-being include determination and inner strength, focus on ability and broadening of horizons, identity and self-concept, activity in nature and ecotherapy, sense of achievement or accomplishment, social well-being, and an enhanced motivation for living (Caddick & Smith, 2014).

Physiological

Physiological biomarker data encompasses a wide list of metrics used to make data-driven decisions in a number of various healthcare settings, generally currently conducted in laboratories and clinical settings. Growth and innovation in technology has spurred the ubiquity of wearable technology, allowing the monitoring of physiology continuously, under natural conditions and in any environment. This ability to gather data outside of the laboratory could unlock troves of new data sets for analysis; however, research studies on data capture through wearable technology are limited. One of the only research studies to use physiological biomarkers was Hignett et al. (2018). Hignett et al. found a positive result through a significant decrease in RHR, indicating an increased level of aerobic fitness among youth participants in their surf therapy study. This finding significantly guided the formulation of research questions for this current study as a result of this literature review.

Qualitative

The qualitative surf therapy research conducted to date has shown an extensive list of benefits to participants, indicating strong early support for the research. Sport and physical activity can support veterans' subjective well-being in many ways, including fostering a sense of achievement and accomplishment (Crawford, 2016). Surfing can provide meaningful benefits to veterans and can protect against more serious problems associated with PTSD, such as suicide. Surfing facilitates a sense of respite from PTSD, and can promote well-being among combat veterans (Caddick et al., 2015b). The social connectedness to fellow surfers also allows participants to experience respite; through the focus required by the activity of surfing, challenge of riding a wave, and the sense of accomplishment, they may view this experience as a small win that could be applied to different challenges (Walter et al., 2020; Weick & Browning, 1986). Caddick and Smith (2014) reported surfing generated positive emotions, evoking feelings of pleasure and joy in veterans. Furthermore, this research appears to be the first to indicate surfing and the blue gym could have a role to play in promoting veterans' well-being.

The challenge–skill balance is an antecedent to flow, which is defined as "the holistic sensation that people feel when they act with total involvement" (Csikszentmihalyi, 1975, p. 36).

Flow state research has demonstrated other modalities of experience—such as art, chess, rock climbing, music, and even team sports (e.g., basketball) and performing live music with others—conjure a host of downstream benefits to participants, including respite, joy, awareness, resilience, subjective well-being, psychological well-being, happiness, fulfillment, and a reduction in anger (Csikszentmihalyi & Csikszentmihalyi, 1990; Sawyer, 2006). Respite conjures similarities to flow because the awareness of the present moment, or state of flow, begins with a condition called *hypofrontality*, which is the temporary deactivation of the prefrontal cortex in the brain. This part of the brain is involved with managing self-criticism, identity, and learned responses. When these activities go quiet, the mind reaches new conclusions and views challenges in a new perspective, potentially shaping accomplishment and achievement toward goals. Through this feeling of respite from suffering through the experience, research has found veterans push PTSD into the background, as exemplified in a comment from a participant from Caddick and Smith's (2017) study:

> It frees you up. It's freedom for those two or three hours. It takes your mind off it. Just leave all that away somewhere on the beach and then we will deal with that later. It is like PTSD does not exist for that short time. (p. 29)

One veteran in another study stated, "I did not think I would stand up on the board, and I did. I wonder what else I can do?" (Rogers et al., 2014, p. 400), which suggests improved psychological resilience. Qualitative researchers have described how their findings illustrate the positive contribution exercise can make to veterans' lives, including how it might enable them to live purposeful and meaningful lives despite the presence of PTSD symptoms (Caddick & Smith, 2017; Hawkins et al., 2016). Nichols (2014), author of *Blue Mind*, shared about the Operation Surf group, "Watching these vets in the water is something else. There is a sense of achievement that destroys their perceived limitations, lifts their self-esteem, brings them together with others like themselves, and rebuilds their psychological strength" (Operation Surf, n.d.-b, para. 6).

Caddick and Smith (2014) used qualitative data to suggest surfing could also influence well-being and psychological health, consisting of two broad categories: subjective well-being and psychological well-being. Subjective well-being encompasses a person's overall satisfaction with life alongside a balance of positive and negative emotions they feel over time (Diener, 2000; Ryan & Deci, 2001). Psychological well-being involves experiences of psychological growth and the fulfillment of human potential (Ryff, 1989; Ryff & Singer, 1998). Caddick and Smith's (2014) research on subjective well-being and psychological well-being allowed consideration of how surfing might have influenced veterans' psychological health beyond the medical emphasis on treating symptoms and disorder. This distinction is important; looking through the medical lens could provide benefit or harm to surf therapy as a treatment modality for veterans in particular.

Qualitative researchers have examined the impact of exercise as medicine and found a number of positive psychological outcomes, such as the capacity of exercise to reduce the clinical symptoms associated with PTSD (Caddick & Smith, 2017). One meta-analysis included research findings that physical activity can significantly reduce PTSD symptoms (Rosenbaum et al., 2015). Other qualitative research revealed various forms of exercise can reduce the symptoms of reexperiencing, avoidance, and numbing; reduce hyperarousal associated with PTSD; reduce anger levels; and improve mental alertness and sleep quality (Dustin et al., 2011; Mowatt & Bennett, 2011; Otter & Currie, 2004).

Qualitative researchers have also demonstrated positive mental health improvements and outcomes by bringing people together and providing opportunities for peer support (Caddick &

Smith, 2014, 2017; Carless et al., 2013; Dustin et al., 2011; Mowatt & Bennet, 2011). The activities can help people to be themselves and relate to others in a way often constrained by the demands of civilian life, which can rekindle military relationships and camaraderie by (a) a sense of acceptance and belonging; (b) a reciprocal obligation to look after the well-being of other group members; and (c) the peer support obtained through the connection, creating important therapeutic implications for the veterans in the studies. Specifically, researchers have supported the use of nature-based physical activity to promote well-being among combat veterans (Caddick & Smith, 2014). In surfing, there is an intertwining (Finlay, 2006; Merleau-Ponty, 1962) of the body with the natural world, which results in embodied and sensory pleasures through the multisensorial stimulation of being active in nature (Caddick & Smith, 2014). The qualitative component of this current research project as an outcome of this literature review was an attempt to expand research on the sensory pleasure through multisensorial stimulation from being active in nature and from the participant veterans' experiences. Furthermore, understanding if flow state or respite were present, and how these factors may have impacted the participant experience, guided the research.

Psychosocial

Outcomes from surf therapy research studies have included improved psychosocial well-being, decreased isolation, and negative symptom reduction (Marshall et al., 2020). Marshall et al. (2019, 2020) conducted two studies involving different programs serving different populations (i.e., vulnerable youth and veterans with combat-related PTSD), where both groups experienced similar outcomes. In terms of psychosocial impacts of surf therapy, Britton et al. (2020) reported enhanced social relationships and prosocial behavior. By combining the active experience of sports skill acquisition with opportunities for reflecting on the experience of acquiring those skills in a group setting, occupation-based programs may act as a catalyst for veterans to construct an alternative narrative of their life experience (Rogers et al., 2014). Surfing provides an ancillary benefit of being a part of a social environment, offering social connection that provides a familial, nonjudgmental, and safe physical and emotional space for participants and fosters experiences that are challenging (Marshall et al., 2020). The camaraderie, sense of belonging, opportunity for peer support, and act of drawing veterans out of social isolation all help to facilitate positive relationships and connection, helping restore confidence and building relationships for improved psychosocial well-being.

Depression, anxiety, PTSD, substance abuse disorders, and high rates of suicide cause significant trouble for communities, especially for individuals who are personally impacted (L. L. Davis et al., 2022). Military culture and stigmas, combined with an underserving of access to care, can exacerbate family issues due to violence and emotional numbing, hampering relationships at increasing numbers and with increasing cost. Alternative therapies show surprisingly positive potential and suggest benefits through programs that can easily scale and remain cost effective; therefore, further research is warranted, including a need for future studies using the ocean, surfing, and the concept of exercise as medicine.

Future State of Research

A critical consideration in surf therapy research is whether surf therapy provides the greatest benefit as an adjunctive or standalone intervention, and for which populations or conditions. Walter et al. (2020) proposed the idea of dismantling designs to determine which components of surf therapy programs account for the greatest amount of change in outcomes. Decoupling the components of surf therapy programs could attempt to build on Caddick and Smith's (2014, 2017) research and Caddick et al.'s (2015a, 2015b) research, identifying the active ingredients of surf therapy that can affect change. One example would be to deliver only the surfing aspect, then to compare it to a surfing therapy program that also included offering the opportunity for social connection and psychosocial intervention (Walter et al., 2020). Adequately assessing and reporting on the use of other interventions by surf therapy participants and determining outcomes for people receiving surf therapy as an adjunctive intervention versus surf therapy alone will help to address the most appropriate dissemination of surf therapy programs. Including comparison groups and randomized controlled trials would greatly increase understanding of the impact on participants in surf therapy programs.

It is essential that future surf therapy studies include repeated and follow-up assessment time points to determine not only the immediate outcomes of surf therapy, but also how long any benefits are maintained (Walter et al., 2020). In doing so, resources and operations can be optimized for the most benefit to participants. Future research should incorporate more rigorous research design elements, standardized assessment measures, and identify the optimal frequency and duration of programs (Walter et al., 2020). Technology could play an interesting role helping with measurement, data capture, and monitoring. Standardizing metrics, either by using the same instruments or creating custom ones for this complex system, would help advance the research.

For surf therapies to greatly expand in size to further understanding of efficacy and impact, will require funding and resources, a standardizing of metrics and focus of the necessary components and variations. Much of this could be accomplished using new technologies to measure therapy effectiveness, but more research will be needed to further understanding. These components and variations include population(s) served, surf instructor preparation and methodology of instruction, dosage of surf therapy (i.e., session frequency, duration, and program length), additional program activities apart from surfing, and outcomes measured

(Marshall et al., 2020). Physiological biomarkers as dependent variables for analysis could further understanding of impact from surf therapy programs. Using innovation in wearable technology could be the next frontier in ability to conduct field research. Using wearables could not only help capture data over a longitudinal period to understand magnitude, impact over time, and how certain dependent variables react and interact with other variables in surf therapy programs, but it could also capture the impacts of participants' treatment plans, other therapies, and even sleep and psychological measures. Further research could examine the presence of flow in surfing compared to other activities such as extreme sports, art, or music to determine if these different activities provide varying levels of benefit and impact in terms of cost, energy, effort, exertion level, and subjective well-being.

U.S. Congress allocated $1 million to the funding of alternative therapies in 2018 and the U.S. Navy is also distributing $1 million to examine surf therapy on active-duty personnel, providing strong momentum for future research. With mental health issues on the rise, cost of healthcare on the rise, medication side effects, while psychotherapy leaves many populations with a desire for another form of treatment, provides fertile ground for research to advance and progress, providing a ripe environment for opportunities in private and public sector investors in search of data-driven and evidence-based outcomes.

For many populations, specifically military veterans, it is imperative to identify alternative approaches to treating depression and other related symptoms that do not rely on traditional psychotherapy and pharmacotherapy. Psychotherapy and pharmacotherapy have efficacious, evidence-based options for individuals with major depressive disorder and other ailments, though some individuals may not have access to, desire for, or benefit from these treatments (Walter et al., 2020). Physical activity, specifically in an outdoor setting, is readily accessible and may address some issues; it could prove beneficial as treatment, in addition to also offering benefits physically and psychologically.

Mental health technology startups pulled in a record breaking $5.5 billion in funding in 2021, up 139% from 2020 (CB Information Services, 2022). The investment deal flow has continued to exponentially rise as well, with 86 deals capitalized at just under $600 million in 2018, growing to over 124 deals in 2020 alone. As the COVID-19 global pandemic has continued to exacerbate mental health issues such as anxiety and depression, demand and investor interest in mental health—specifically, in digital tools that enhance mental healthcare delivery—are expected to grow. This private sector capital infusion data, combined with the aforementioned funding through the U.S. Navy for active-duty personnel and other alternative therapy treatment studies, build a strong framework for the research component to grow, both in volume and rigor. Combining this growth in research and funding with the VA calling suicide a national crisis and initiatives to do more with less, rigorous research is not only justified, but is also critical to help.

Finally, the COVID-19 global pandemic and collective psychological fallout may be the necessary catalyst to finally push mental health into the mainstream, rapidly moving discussion to the forefront and further justifying the need for rigorous research. For all populations, including active duty servicemembers, military veterans, and civilians of the community as a whole, it is imperative to identify alternative approaches that may help mitigate psychological, physical, and psychosocial issues such as depression, anxiety, and stress.

As a result of conducting this literature review, I aimed to use this research project to help provide evidence and build on the existing knowledge base, increase the scientific rigor of the body of research, generate additional data for analysis, inform public policy, and create evidence-based data to further understand and improve care. Literature to date on surfing has been limited by reliance on self-report measures. Collecting physiological data could serve to validate data collected through self-report assessments and also allow for a more comprehensive examination of the range of outcomes that may be impacted by engaging in outdoor physical activity (Walter, Otis, Glassman, et al., 2019).

The research findings of this current study could benefit veterans, their families, and the community as a whole through their impact, exhibited at the community level through policy changes, causing a shift in financial resources. At the community level, surf programs could increase productivity, improve economics, and reduce healthcare costs. At the personal level, it could reduce PTSD symptoms, depression, anxiety, risk-taking behaviors, thrill seeking, opioid use, and suicide, all in a potentially highly scalable format. This research lies at a valuable intersection of creative delivery format with elements that have been hypothesized to have health benefits for generations, but until now researchers may have never had the tools to harvest the necessary data. The advancement of technology may provide the ability to uncover the importance of this work and help implement meaningful change and impact at all levels of society.

CHAPTER 3: METHODOLOGY

The United States is confronting an unprecedented mental health crisis. Prior to the COVID-19 global pandemic, mental health issues such as depression and anxiety were increasing (Merikangas et al., 2020). Mental health concerns continue to exacerbate many associated conditions, causing an increase in both cost and need for care. The Centers for Disease Control and Prevention reported a series of disproportionately worse mental health outcomes for the United States in 2020, including increased substance use and elevated suicidal ideation; specifically, 11% of adults in the United States considered suicide, and an alarming 40% said they were struggling with mental health or substance abuse (Czeisler et al., 2020).

Although many different populations are impacted by these conditions, one specific population at especially high risk for mental health conditions and substance abuse is the military community, both active duty and veterans, due to the events witnessed during combat. Veterans face high rates of posttraumatic stress disorder (PTSD) and suicide (Hester, 2017). With the increase in PTSD cases in the United States throughout the 2000s and 2010s there is a constant motivation for mental health agencies in the United States to seek therapeutic activities for individuals with PTSD that do not involve pharmaceuticals, alcohol, or illegal drugs, particularly for combat veterans (Crawford, 2016; Rogers et al., 2014).

During his second inaugural address, President Lincoln made a promise “to care for him who shall have borne the battle, and for his widow, and his orphan” (U.S. Department of Veterans Affairs [VA], n.d.-d, para. 5), affirming the government’s obligation to care for people injured during war and to provide for families who perished on the battlefield. Similarly, during President Biden’s first State of the Union speech, he addressed the national mental health crisis; one of the four specific points he discussed included supporting veterans (The White House, 2022a). This research study supported President Lincoln's and President Biden's promises by serving and honoring the veterans of the United States.

This study expanded on the work of Crawford (2016) and Rogers et al. (2014), who examined the effect of ocean therapy, a type of nature-based therapy that primarily uses surfing as the treatment modality for military veterans and Nichols's (2014) notion of the helpfulness of being on, near, or around water. For this research study, I gathered data for analysis and examined the psychological, physical, and psychosocial impact of ocean surf therapy through the use of surveys, physiological biomarkers, and qualitative data. The study was built on the infrastructure of an existing program (i.e., Operation Surf) and capitalized on existing volunteer resources, location, accessibility, and surf instructors.

Based on the aims of this study, I formulated the research questions to examine the impact participation in an Operation Surf weeklong surf program experience had on self-reported levels of PTSD, depression, and anxiety for veterans with PTSD. I gathered data through the administration of surveys. I also gathered quantitative physiological data (i.e., heart rate variability [HRV], resting heart rate [RHR], rapid eye movement [REM] sleep, and deep sleep) through wearable technology. Several types of qualitative data helped provide greater insight, context, and understanding of the overall experience and helped explain any discrepancy in the quantitative data. For this research study no specific discrepancies were suggested but more research is needed.

In this chapter, I begin with an explanation of the research methodology and design and then move to the site and sample selection procedures. Next, I detail the research questions and details of the data collection and analysis procedures, including details on the instruments used to collect data, and the validity and reliability of these instruments. The chapter closes with discussion of the limitations and significance of this study.

Research Design and Methodology

For this study, I used wearable technologies, the concept of exercise as medicine, and the use of blue space interventions to measure therapy effectiveness through examining the use of nature-based therapy modalities for the treatment of physical and psychological conditions in people with symptoms such as sensation-seeking behaviors. Specifically, I used new technology to gather data to measure therapy effectiveness of the impact of Operation Surf's weeklong ocean surf therapy programs on military veterans with PTSD. I used participant activities, measured unobtrusively through wearable technology that gathered physiological biomarker data, supplemented with self-reported survey data gathered at three distinct points in time, to measure physiological and behavioral change among participants. In addition, I gathered qualitative data continuously during the weeklong intervention and in group chats that began at event orientation and continued throughout the event and afterward.

This research project featured an embedded mixed methods design, which combined the collection and analysis of quantitative and qualitative data in a traditional quantitative research design (Caracelli & Greene, 1997). I conducted the quantitative research in two longitudinal ways: (a) a series of participant-completed surveys, and (b) the capture of physiological data through a partnership with Whoop, unobtrusively gathering sleep, fitness, and health data. I included qualitative data to give a voice to participants, resulting in (a) greater insight and understanding of the overall experience; (b) a verbal description of why changes, if any, occurred; and (c) information about what programmatic changes might be beneficial for longer-lasting results. These data were gathered primarily through observation as part of several components of a mini-ethnographic multicase study, which included time spent with participants during the course of the six cohorts of Operation Surf's weeklong surf camp, and through conversations, field notes and textual analysis of GroupMe text message chats shared among participants during and beyond the course of the week.

The three surveys used in this research study included the General Anxiety Disorder Scale (GAD-7), the Patient Health Questionnaire Eight (PHQ-8), and the Patient Checklist for PTSD (PCL-5; see Appendix; Kroenke et al., 2009; Spitzer et al., 2006; Wortmann et al., 2016). I administered each survey three times via the online survey platform, Qualtrics (https://www.qualtrics.com): once prior to participation in the event, once after participation in the program, and once at 30 days after participation in the ocean therapy program. Time Point 1 was the reported score prior to the event. Time Point 2 was the survey score immediately after the event. Time Point 3 was the survey score reported 30 days after the event. I collected the physiological biomarker data in the week before the event, during the event, and after the event. The time before the event served as Time Point 1, the time during the event served as Time Point 2, and 30 days after the event served as Time Point 3.

The quantitative physiological biomarker data were collected through Whoop bands given to participants. These data were available to participants through their web portal on the Whoop website and was exported from the whoop data team to the researcher in .csv format. The data collected includes HRV, RHR, and REM and deep sleep data. The physiological data were collected during the same period as the self-report survey assessments, for a period before, during, and 30 days after the event. Time Point 2 data for the physiological biomarkers were collected during the event, whereas the survey data were collected immediately following the event.

I analyzed the collected quantitative data using paired samples *t* tests for the survey data and the physiological biomarker data. For each paired samples *t* test, the Time Point 1 scores were used individually as the dependent variables. The Time Point 2 and Time Point 3 scores were also used as the dependent variables. The independent variable was the subjects' participation in ocean therapy. The single group studied included PTSD diagnosed military veterans who participated in an ocean surf therapy program with Operation Surf from May 2021 through May 2022.

This research project is built upon previously conducted research examining surf therapy (Crawford, 2016; Rogers et al., 2014). Although Rogers et al. (2014) did look at how a structured surfing program could affect the mental health of veterans with PTSD, the study was limited by sample size ($n = 14$). Crawford (2016) expanded research in the field to a sample size of 95 but captured data only through the highly subjective self-report survey assessment tools. Hignett et al. (2018) in the United Kingdom found the positive benefit of significant drops in heart rate with the results suggesting surfing interventions could have important benefits for at-risk youth. At the time of the study, research using physiological biomarker data, especially outside in the field from wearable technology, is limited, but early results appear promising. These initial early positive results—in conjunction with the innovation in technology through rapid advancement in hardware, software, and the ubiquity of mobile devices—could yield incredible insight and foster entirely new frontiers in data and healthcare, furthering understanding, advancing diagnostic and therapeutic capabilities, delivering more effective and efficient health care services, and ushering in salubrious effects.

Additionally, strong qualitative data from research conducted in the United Kingdom showed how surfing, one application of the blue gym concept (i.e., exercise outdoors in nature), could influence well-being among a group of combat veterans experiencing PTSD, resulting in rich, storied data (Caddick & Smith, 2017). These studies (i.e., Caddick & Smith, 2017; Crawford, 2016; Rogers et al., 2014) created a solid foundation to build upon for this research study. This research study will incorporate various components of each, but also including additional data collection strategies, featuring both quantitative and qualitative data, further advancing scientific knowledge of the domain.

Sites and Sample Selection Procedures

Operation Surf has traditionally held three distinct weeklong surf experiences throughout the year in various supportive beach communities in California such as Santa Cruz, Huntington Beach, and San Luis Obispo (Operation Surf, n.d.-c). The events have typically included about 25 wounded military veterans and active-duty military as participants and has provided an environment where participants can work to overcome perceived limitations connected to their physical and psychological disabilities. Participants are vetted through an application process and selection criteria, which is explained in detail on the Operation Surf website. However, due to the COVID-19 global pandemic that began in 2020, the traditional event had to be modified quite significantly. Many important key activities, such as the welcome parade, no longer occurred due to California government restrictions preventing large gatherings because they posed an especially high danger of transmission and spread of the COVID-19 virus.

Fortunately, the state of California deemed Operation Surf as an essential business activity as of September 1, 2020. The key decisionmakers of Operation Surf met and discussed the feasibility of holding events, and the need for such events, because the effects of the COVID-19 global pandemic were unknown on the population of veterans with PTSD. The executive team decided to move forward and conduct surf experience events. I worked closely with the

Operation Surf team to plan and conduct data collection at Operation Surf events, beginning in May 2021 in Avila Beach, near San Luis Obispo, California. The initial event included a reduced number of participants (n = 8) to stay within state government guidelines for operating during the pandemic. The research study targeted all 32 Operation Surf participants throughout 2021 (i.e., eight participants at each of four events), and an additional 16 participants through March 2022 and May 2022 events, for a total of 48 military veteran participants.

I recruited participants for this study using a nonprobability sampling strategy. In nonprobability sampling, study participants are selected based on availability, accessibility, convenience, and the fulfillment of the inclusion criteria for the study (Callegaro et al., 2014). All participants in the surf camp were offered the opportunity to participate in the study; in advance of the Operation Surf events, they were sent an invitation to participate in the study. The correspondence included the purpose of the study, why they were being invited to participate, what was required to participate in the study, and the time commitment and significance of the study. Correspondence included a copy of the informed consent letter outlining the policies and procedures that were to be implemented to protect participant welfare, privacy, and data confidentiality. I invited all attendees to participate in both the quantitative and qualitative data collection activities and notified them they could withdraw from the assessments or program at any time without any explanation. To withdraw from the study, they could simply choose not to open emailed web links to complete the voluntary self-report assessments, or they could opt not to wear their Whoop band. Additionally, I emphasized the voluntary nature of participation through all communication related to the event.

Research Questions

I formulated the research questions for this study to evaluate the impact of participating in an ocean therapy program for veterans with PTSD. Data collection included (a) assessment of psychological symptoms (i.e., PTSD, depression, and anxiety) through the use of surveys; (b) monitoring physiological biomarkers (i.e., HRV, RHR, and REM and deep sleep), gathered through Whoop wearable technology, using new technology to measure therapy effectiveness; and (c) examining psychosocial impact through analysis of qualitative data. The research questions for this study were:

- Research Question 1: To what extent, if any, is there a change in PTSD symptoms, depression, or anxiety among veterans who participate in Operation Surf as measured by the PTSD Check List (PCL-5) assessment, the Patient Health Questionnaire Eight (PHQ-8), and the General Anxiety Disorder Scale (GAD-7), at three points in time?
- Research Question 2: To what extent, if any, is there a change in physiological biomarker data among veterans who participate in Operation Surf?
- Research Question 3: To what extent, if any, does the qualitative data help explain any discrepancies in the quantitative data from the first two research questions?

Data Collection Procedures

Participants for this research study were chosen by Operation Surf to attend a weeklong ocean surf therapy program between May 2021 and May 2022. In the following sections, I outline how the data was collected, what software was used to assist in data collection, and the procedures I conducted in attempt to answer the research questions. The following sections explain both the quantitative measures and the qualitative measures used for this research study in greater detail.

Quantitative Measures

I conducted the quantitative measures in two longitudinal ways: (a) a series of participant-completed surveys; and (b) the capture of physiological data through a partnership with Whoop, unobtrusively gathering sleep, fitness, and health data. This section explains the quantitative measures used for this research study in greater detail.

Surveys

This study included a quantitative research design using paired samples *t* tests to examine the relationships between the study variables over time as a function of participation in an ocean surf therapy program. The within-subject variables included PTSD symptoms, depression, and anxiety, and were collected through surveys at three specific points of time: prior to the intervention (i.e., Time Point 1), at the conclusion of the weeklong intervention (i.e., Time Point 2), and approximately 30 days after the intervention ended (i.e., Time Point 3). These data were combined with the physiological biomarker data collected through Whoop wearable technology, including RHR, HRV, and sleep data (i.e., REM and deep sleep). For the physiological biomarker data, I used a similar strategy as the survey data, using paired samples *t* tests to examine the relationships between the study variables over time as a function of participation in an ocean surf therapy program. The within-study variables (i.e., HRV, RHR, and REM and deep sleep) were collected across the entire spectrum of the research study (i.e., at Time Points 1, 2, and 3).

For the physiological biomarker data, I calculated and used the means for statistical analysis. In this study, individuals served as their own controls, with initial measurements of the subjects' PTSD symptoms, depression, and anxiety serving as the baseline at Time Point 1. For the physiological biomarker data, initial measurements of calculated means from Time Point 1 served as the baseline prior to the intervention.

The study used three different surveys for the self-reported quantitative data: (a) PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders V (DSM-5; i.e., PCL-5), (b) Patient Health Questionnaire Eight (i.e., PHQ-8), and (c) General Anxiety Disorder Scale (i.e., GAD-7). The surveys are described in the sections that follow.

PCL-5. PCL-5 is a 20 item self-report measure that corresponds to the 2013 published DSM-5 and is used to measure the severity of PTSD symptoms. The PCL-5 was created by the VA National Center for PTSD (2010) and takes approximately 5 minutes to complete (Weathers et al., 2014). Symptoms are measured using a 0–4 scale with higher scores suggesting greater severity of symptoms, and the sum of all the scores indicating overall symptom severity. A 5-point pretest to posttest difference is considered significant, but a 10–20-point change is clinically meaningful (Weathers et al., 2014). The PCL-5 has high internal consistency ($\alpha = .94$), good test–retest reliability ($r = .82$) and research has suggested the PCL-5 possesses strong, robust psychometric properties, supporting its use as a brief self-report measure of PTSD symptomology (Blevins et al., 2015; Keen et al., 2008).

PHQ-8. The Primary Care Evaluation of Mental Disorders (PRIME-MD) was developed and validated in the early 1990s to efficiently diagnose five of the most common types of mental disorders presenting in medical populations: depression, anxiety, somatoform, alcohol, and eating disorders (Spitzer et al., 1994). Building upon this instrument through two large studies enrolling 6,000 patients, a self-administered version of the PRIME-MD (i.e., PHQ) was developed and validated (Spitzer et al., 1999, 2000). This PHQ-9 has been shown to be a reliable and valid measure of depression severity (Kroenke et al., 2001). The instrument used in this study, the PHQ-8, included all items of the PHQ-9 except the ninth item on self-harm, which was viewed by our Operation Surf team including myself and my dissertation committee as inappropriate for this population. Fortunately, the 8-item PHQ-8 has been shown to be a valid diagnostic and severity measure for depressive disorders in large clinical studies (Kroenke et al., 2009).

Scoring of the PHQ-8 is done by assigning scores of 0, 1, 2, and 3 to the response categories of *not at all*, *several days*, *more than half the days*, and *nearly every day*; when the scores are added up, they result in a total score of between 0 and 24, with higher scores associated with greater levels of depression (Kroenke et al., 2001). These total scores can be interpreted using the following scale: (a) 0–4 represents no significant depressive symptoms, (b) 5–9 represents mild symptoms, (c) 10–14 represents moderate symptoms, (d) 15–19 represents moderately severe symptoms, and (e) 20–24 indicates severe symptoms.

GAD-7. Generalized anxiety disorder (GAD) is considered one of the most common mental disorders. The popular 7-item GAD-7 measures severity of anxiety. Originally created by Spitzer et al. (2006), the 7-item anxiety scale has strong reliability ($\alpha = .92$) and strong criterion, construct, factorial, and procedural validity. Scoring of the survey is done by assigning scores of 0, 1, 2, and 3 to the response categories of *not at all*, *several days*, *more than half the days*, and *nearly every day*; when the scores are added up, they result in a total score of between 0 and 21, with higher scores associated with greater anxiety. These total scores can be interpreted using the following scale: (a) 0–4 represents minimal anxiety, (b) 5–9 represents mild anxiety, (c) 10–14 represents moderate anxiety, and (d) 15–21 represents severe anxiety.

Data Collection

Three instances of survey data collection occurred through Qualtrics: once at Time Period 1, once at Time Period 2, and again at Time Period 3. I calculated the total scores for each of the three measures (i.e., PCL-5, PHQ-8, and GAD-7) as described in the previous section. I analyzed the collected data using a paired samples *t* test at the $p \leq .05$ significance level with the total scores at three points in time serving as the dependent variable in the paired samples *t* test.

In addition to the survey data collected, this study employed wearable technology to capture physiological biomarker data continuously throughout the data collection period. Wearable technology consists of a smart electronic device (i.e., electronic device with a microcontroller) worn on or close to the surface of the skin where it detects, analyzes, and transmits immediate biofeedback information (O'Donoghue & Herbert, 2012). Specifically, the study used a Whoop band for this wearable technology. The biomarker data collected included HRV, RHR, and two stages of sleep (i.e., REM and deep). Participants wore the bands for a period of up to 14 days prior to the surf camp, during the event, and for 30 days following the event. The collected data were analyzed using paired samples *t* tests. The Whoop band itself is a wearable device that collects continuous heart rate data through advanced sensors, including green light-emitting diodes to measure blood flow, a 3-axis accelerometer, and a 3-axis gyroscope to measure emotions (Whoop, 2017). In combination with the Whoop mobile device application and cloud-based analytics platform, a series of algorithms evaluated HRV, RHR, and duration and phases of sleep. Validation of sleep and cardiovascular measures from Whoop against gold standard polysomnography supported a low degree of bias and low precision errors (Berryhill et al., 2020; Miller et al., 2020). Whoop calibrates to a baseline for personalized feedback based on the user's recovery, strain, and sleep. The device is waterproof with a rechargeable battery.

Whoop calculates HRV using a dynamic average combined with RHR each night while sleeping, focusing on the last slow wave sleep stage, or the period of deepest level of sleep (Whoop, 2017). This calculation method enables users to get an accurate understanding baseline from which to monitor trends and abnormalities. HRV is determined by the time between heart beats, known as *RR intervals*, which are named after a heartbeat's R-phase, or the spikes on an electrocardiogram. The periods of time between successive heart beats are RR intervals and are measured in milliseconds. Whoop calculates HRV using the root mean square of successive differences between heartbeats (Shaffer & Ginsberg, 2017).

Taken together, the Whoop device measured RHR each night using a dynamic average weighted toward the last period of slow wave (i.e., deep) sleep, when the body is in its most restful state. The respiratory rate during sleep, reported as respirations per minute, was also measured over the course of the night while sleeping. Whoop calculated respiratory rate from the raw heart rate data by taking advantage of a phenomenon called respiratory sinus arrhythmia (Capodilupo, 2021). When humans breathe in, their heart rate increases, and when they breathe out, it decreases. This phenomenon allows the body to preferentially pass blood through the lungs when they are full of oxygen. Because the autonomic nervous systems increase heart rate during inhalation and decrease it during exhalation, respiratory rate can be seen in the continuous heart rate data by looking for this cyclical pattern of increasing and decreasing. And finally, the wearable band also captured sleep data; specifically, it examined how much time was spent in each sleep stage (i.e., light, REM, slow wave/deep, and awake) per night. For this research study, the sleep cycles of REM and deep sleep were analyzed.

Qualitative Measures

De Vos et al. (2005) shared:

> [The analytical process] does not proceed tidily or in a linear fashion but is more of a spiral process; it entails reducing the volume of the information, sorting out significant

> from irrelevant facts, identifying patterns and trends, and constructing a framework for communicating the essence of what was revealed by the data. (p. 333)

With this quote in mind, I acquired the qualitative component of this research study through a mini-ethnographic study that was exploratory in design. I examined a collective of six case studies of event participant cohorts using field notes from participant observation; verbal, nonverbal, and informal conversations; interviews; and GroupMe text message chat transcripts. The results emerged through data triangulation across several components. The qualitative data analysis component of this mixed methods study was a process of gathering, structuring, and interpreting the rich qualitative data to understand what it might represent. I used thematic analysis to deepen understanding of the participants' experiences and complement the quantitative data. This process helped me discover repeating themes and accomplish a winnowing of the data to reveal key insights through the use of several sets of codes. Then, I used the coding to describe emerging themes.

For the coding of the qualitative data, including the GroupMe text message chats I used inductive coding, open coding, while creating codes as they arose from the data set. I would read and reread GroupMe chats along with field journals, from out in the water surfing with the veterans and on the beach between sessions as well as from dinners shared together in the evenings and from driving them as the volunteer shuttle driver for the event. Inductive coding where the coding is derived from the data as it occurs, which helps the exploration of the subject to flow. In the initial coding stage, while observing and participating in the ocean surf therapy events, I created a general overview of the data creating early sets of codes. Then later I conducted line by line coding, delving deeper into the data and reorganizing it according to new codes. As new data would come in, I would apply the codes from the previous texts and journals, then when needed I would create new codes. Occasionally I would split a code into two or combine codes. The thematic analysis using the inductive coding was very much an iterative process, but also gave me an unbiased complete snapshot of the themes throughout the data. GroupMe text chats occurred from the group with greater frequency closer to their event so these transcripts were revisited after every event. The process was ad hoc and ongoing through the entire study duration from May 2021 through May 2022, helping me discover repeating themes and accomplish a winnowing of the data to reveal key insights using several sets of codes.

Thematic analysis was applied to the codes to further understanding, and the data were analyzed according to the research question posed previously in the study. The themes emerged from what was learned and observed during coding, drawing meaning from the data, which started to produce a narrative.

The field notes journals and GroupMe text chat application transcripts supplemented the process to offer rich, detailed insight and quotes to serve as examples to further meaningful insight. The qualitative data collection strand began during Operations Surf's in-person event because I believed this timing would help the level of interaction while the event was being conducted. The goal of the qualitative data collection was to observe and learn during the events, which were immersive in nature with all meals and surf sessions conducted together as a captive audience for the entire duration, creating time and opportunity for me to observe and communicate with participants. I participated ethnographically as a volunteer at the weeklong events. I was a shuttle driver for the veteran participants, driving them to and from dinner and surfing every day. A classic ethnographic study can take years to complete because the researcher needs to become part of the culture, requiring not only significant time, but also budget for execution (Jiménez-Luque, 2018). As a result of the requisite time and money necessary to undertake an ethnographic research study, I instead focused on a mini-ethnographic study. Mini-ethnography is a research design that aims to understand cultural norms, values, and roles as are relevant to what participants remember (K. L. White, 2009). Mini ethnography was created as an alternative to classic ethnographic studies because it can be conducted in 1 week, 1 month, or up to 1 year (Storesund & McMurray, 2009).

I conducted research at the six Operation Surf ocean surf therapy programs from May 2021 through May 2022. This 1-year timeframe allowed for a longitudinal approach to observe and record changes while collecting data in a natural setting focused on verbal and nonverbal behaviors. Access as a volunteer for the events, specifically as a shuttle driver as well as my occasional role helping as water safety while surfing, allowed me to gain access to conduct the study, which would have been closed to other forms of research. I believed this form of research and immersion into the Operation Surf events provided detailed and rich data that could springboard into further studies. This volunteer role provided me regular access and time alone with participants to perform data collection. These data were conducted in the form of semistructured interviews, both conversational and in person.

Additional qualitative data were collected through participant observation, field notes, and program data. Participant observation entailed that I, as the researcher, observed and participated in the daily activities of the veterans during all weeklong event programs, in which I actively immersed myself in the group environment and joined in the activities, including yoga and meditation sessions on the beach prior to surf instruction. Following the weeklong events I observed, I used field notes to document the findings, resulting in approximately 40 hours of observational data for every event, across all six in-person events. I used participant observation because it enabled insight into the mundane, the typical, and the occasional extraordinary features of everyday life in the context of the group (Smith et al., 2014). I used follow-up email and phone conversations as necessary for clarification, but primary data collection occurred in person during the weeklong event.

For this study, I also used GroupMe, a phone application for facilitating group texts, for event communication, and as a method to discuss and capture program data. This platform allowed for efficient and rich data capture, recording conversations into a phone text chain for easy capture and analysis. The application text was searchable, and had authors, dates, and time stamps on all communication. GroupMe text communications allowed me to use the process of thematic analysis to encode information using themes and assisted me in the search for insight. The data were then analyzed according to the research questions posed previously in the study—with the third research question in focus for the qualitative component—in an attempt to understand to what extent, the qualitative data can help to explain any discrepancy in the quantitative data. The results are discussed in the following chapter.

Integrating the Quantitative and Qualitative Strands

The relative priority of the quantitative and qualitative strands were equal because they both provided complementary value and helped further understanding of the experience of the participant and the impact of the event. The timing of the quantitative and qualitative strands was concurrent because the quantitative data collection began prior to the in-person surf camp event and continued throughout the event week and following the event for 30 days. The qualitative data collection began during the in-person surf camp event week and continued following the event via emails, phone conversations, and GroupMe text communication for clarification and follow up if necessary. Although the two strands of data collection occurred simultaneously during the event and after, the strands did not directly interact with each other until after the data had been collected and were analyzed and reported.

Data Analysis Procedures

The data analysis phase required time to prepare data, including the physiological data export files from the Whoop technology, and the survey data recorded and collected via Qualtrics. After the data were collected, organized, and validated, I conducted paired samples *t* tests for the statistical analysis to answer the first two research questions of the study. However, prior to the inferential analysis, I first calculated descriptive statistics to determine whether the data met the statistical assumptions required for paired samples *t* tests, including tests for independence, the absence of significant outliers, homogeneity of variances, and the normality of the dependent variables. I accomplished these calculations through the use of the SPSS software platform (https://www.ibm.com/spss). To address the third and final research question, I used qualitative techniques such as participant observation, interviews, and document analysis to make sense of the results from the quantitative phase of the research. The iterative process of conducting thematic analysis of the GroupMe chat transcripts and reviewing the field journals of observational data and semistructured interviews began with immersing myself in the data by reading closely and rereading to gain familiarity with the data. These techniques are described in further detail on a research question by question basis in the following sections.

Research Question 1

The first research question of the study sought to determine to what extent, if any, there was change in PTSD symptoms, depression, or anxiety among veterans who participated in an Operation Surf program. To address this research question, I conducted paired samples *t* tests using the GAD-7, PCL-5, and PHQ-8 scores as the dependent variable and time (i.e., Time

Period 1, Time Period 2, and Time Period 3) as the within-subject variable. I conducted these tests at the $p \leq .05$ level of statistical significance. The results of this analysis were used as the basis to determine whether participation in Operation Surf's program resulted in statistically significant changes in the PTSD symptoms, depression, or anxiety of veterans. In addition to statistical significance, I also employed clinical analysis specific to each survey using diagnostic scoring methods to understand if any clinically significant changes occurred.

Research Question 2

The second research question of the study sought to determine to what extent, if any, there was a change in physiological biomarker data among veterans who participated in Operation Surf. To address this research question, I conducted paired samples *t* tests using the physiological biomarker data as the dependent variable and time (i.e., Time Period 1, Time Period 2, and Time Period 3) as the within-subject variable. I conducted these tests at the $p \leq .05$ level of statistical significance. The result of this analysis was used as the basis to determine whether participation in Operation Surf resulted in statistically significant changes in physiological biomarkers of veterans. I conducted additional analysis using the mean of the point in times for individuals, and the minimums, maximums, and means for all individual participants. I also conducted analysis by cohort and by gender to segment the data in an effort to further understanding.

Research Question 3

The third research question of the study sought to determine to what extent the qualitative data helped explain any discrepancies in the quantitative data from the first two research questions. To address this research question, I conducted data triangulation across a number of various components including exploratory research with thematic analysis to deepen understanding of the participants' experiences. I conducted participant observation by immersing myself in the group environment. I collected field notes to document the findings, resulting in observational data. I also used the GroupMe text messaging phone application for qualitative data capture when myself and participants were immersed during the residential weeklong surf camp and after the events for easy communication.

Limitations

There were several limitations in relation to this study. The major limitation of this study was the intervention was not a randomized controlled trial; however, allowing individuals to serve as their own controls moved this study into the realm of a quasi-experimental design. Another key limitation was the nonprobability sampling strategy I used, which limited the study to the 48 veterans who enrolled in the ocean surf therapy program with Operation Surf from May 2021 through May 2022. As a result, there may have been selection effects because veterans who tend to enroll in alternative therapy such as Operation Surf event might also be veterans who are actively trying to assimilate into civilian life, and/or veterans who are more open and receptive to treatments for PTSD. These veterans may embody a more positive attitude and hope toward recovery, which could affect their PTSD symptoms, depression, and anxiety. As such, the findings of this study may not necessarily be generalizable to all veterans.

In addition, as the researcher for the study, I served as volunteer shuttle driver and water safety person for participants during the event; thus, it is unclear to what extent social desirability on the part of participants may have influenced their responses to several of the outcome measures. Lastly, the COVID-19 global pandemic and the concomitant cancellation and scaling back of many of the key activities of Operation Surf's camp, including the number of participants reduced as mandated by the state of California, may have reduced the power of the intervention.

Significance

There has been limited study into methods such as Operation Surf, ocean therapy, and nature-based treatments on military veterans with PTSD. Although a handful of quantitative survey studies have been conducted, none have included physiological data collection. The opportunity to use biomarker data in this study to either corroborate or refute the results of the self-reported surveys represented a major contribution to the empirical literature.

The results of the intervention show strong promise and healthy benefit in reducing anxiety, depression, and PTSD symptoms among participants—as well as improving physiological biomarker data such as increasing sleep or increasing HRV—this study design could lend credibility toward a new treatment modality that has the potential to increase the quality of life for PTSD-afflicted veterans, their families, and their friends and peers. Using new technologies such as wearable technology to measure therapy effectiveness could also signify a major contribution to the empirical literature. Given the amount of funding distributed annually in hopes of improving quality of life for millions of military veterans, and rising costs and shrinking budgets, this research played an important role and justified additional resources to further understanding. In addition to complex issues such as lack of access and barriers to care, and a stigma to treatment, offering low cost, easily replicable, and enjoyable activities such as surf camps could help to alleviate the burden and cost of health care. This research could also inform public policy care decisions and enrich the decision-making process globally, saving lives through reducing suicide risk.

CHAPTER 4: DATA ANALYSIS AND RESULTS

Mental health is quickly becoming a major global concern due to the prevalence and impact it has on community, society, and the health of individuals. Concerns for mental health and its many associated conditions (e.g., anxiety, depression) have been exacerbated by the ongoing COVID-19 global pandemic, which has caused increases in both need for care and cost of care. The Centers for Disease Control and Prevention reported a series of disproportionately worse mental health outcomes for people in the United States in 2020, including increased substance use and elevated suicidal ideation; specifically, 11% of U.S. adults considered suicide, and an alarming 40% said they were struggling with mental health or substance abuse (Czeisler et al., 2020).

Although many different populations are impacted by mental health conditions, one specific population that is especially high risk for mental health conditions and substance abuse is the military community, both active duty personnel and veterans, due to the events they witness during combat. Veterans face high rates of posttraumatic stress disorder (PTSD) and suicide (Hester, 2017). With the increase in PTSD cases in the United States since 2000 there has been a constant motivation for mental health agencies in the United States to seek therapeutic activities for individuals with PTSD—particularly for combat veterans—that do not involve pharmaceuticals, alcohol, or illegal drugs (Crawford, 2016; Rogers et al., 2014). Although several pharmacological approaches have been employed to combat this epidemic, their efficacy is mixed at best, which has led to several novel, nonpharmacological approaches.

One nonpharmacological approach is Operation Surf, a nonprofit organization that provides nature-based programs advocating the restorative power of the ocean and surfing as a form of wellness for injured bodies, minds, and souls (Operation Surf, n.d.-a). To understand the efficacy of Operation Surf, the purpose of this mixed methods study was to collect data for analysis and insight using new technologies to measure therapy effectiveness. Specifically, the purpose of this study was to understand how Operation Surf's weeklong ocean surf therapy program impacted psychological, physical, and functional outcomes for veterans seeking mental health treatments for symptoms of PTSD. Thus, I used survey data to measure changes in depression, anxiety, and PTSD—together with data generated from Whoop bands—to produce a more robust set of programmatic efficacy inferences for six cohorts of military veterans who participated in Operation Surf from May 2021 through May 2022.

This study built on the infrastructure of an existing program (i.e., Operation Surf) and capitalized on existing volunteer resources, location, accessibility, and surf instructors, while expanding on the work of Crawford (2016) and Rogers et al. (2014), that examined the effect of ocean therapy. In addition to surveys and biometric data, I also conducted qualitative research to include participant voices, resulting in greater insight and understanding of their overall experience. This research also produced a verbal description of why changes, if any, occurred, and what programmatic changes might be beneficial for longer lasting results.

In this chapter, I present descriptive and summary statistics for the collected data at each time point, followed by an inferential analysis using paired samples *t* tests to answer the first two quantitative research questions. Then, a qualitative section follows to address the third and final research question. Chapter 5 includes a more robust discussion of what the data means.

Descriptive Data

In this section, I outline the descriptive data for the quantitative research questions gathered through surveys, then data collected through the Whoop wearable technology. This section includes tables to show the data used for analysis, including means and standard deviations for the three points in time along with the sample size. Time Point 1 was the reported score prior to the event. Time Point 2 was the survey score immediately after the event. Time Point 3 was the survey score reported 30 days after the event.

Surveys

First, I exported data from Qualtrics as a comma separated values (i.e., .csv) file, then converted it to Excel format to generate the Patient Health Questionnaire Eight (PHQ-8), PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders V (DSM-5; i.e., PCL-5), and General Anxiety Disorder Scale (GAD-7) for each subject. All participants in Operation Surf's program who were military veterans were eligible to participate. People between the ages of 20 and 55 participated in the study. I contacted a total of 41 military combat veterans for survey participation. I imported data into SPSS 28 for summary statistic generation and testing of statistical assumptions. Due to the nature of these surveys, the analysis was twofold: I computed and analyzed both statistical and clinical significance. For determining statistical significance, I compared and analyzed scores using paired samples *t* tests to compare the scores for each subject across the three points in time. These paired samples *t* tests compared the means of two measurements taken from the same individual. For clinical analysis and clinical significance determinations, I used the associated guidelines for each survey to determine diagnostic and severity measures. These processes are discussed in greater detail in the results sections pertaining to each survey later in this chapter.

PHQ-8

The means and standard deviations of scores for the PHQ-8 at each time point are presented in Table 1 as the product of paired samples statistics, comparing the points in time. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All 41 participants completed the ocean surf therapy program, but not all participants answered the surveys at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where the means and mean differences were compared. I also segmented and analyzed data by gender and individual cohort. The means, sample sizes, and standard deviations for gender are shown in Tables 2 and 3. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 1

Descriptive Statistics for PHQ-8 at Three Points in Time

	Pair	*M*	*n*	*SD*
1	Time Point 1	11.12	17	4.68
	Time Point 2	6.18	17	4.13
2	Time Point 2	8.44	18	5.48
	Time Point 3	9.11	18	6.06
3	Time Point 1	12.15	20	5.32
	Time Point 3	8.50	20	4.51

Table 2

Descriptive Statistics for PHQ-8 at Three Points in Time, Female Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	12.50	4	2.65
	Time Point 2	6.25	4	2.63
2	Time Point 2	10.83	6	7.08
	Time Point 3	10.50	6	7.26
3	Time Point 1	15.60	5	4.16
	Time Point 3	10.60	5	2.41

Table 3

Descriptive Statistics for PHQ-8 at Three Points in Time, Male Participants

Pair		*M*	*n*	*SD*
1	Time Point 1	10.69	13	5.15
	Time Point 2	6.15	13	4.58
2	Time Point 2	7.25	12	4.35
	Time Point 3	8.42	12	5.58
3	Time Point 1	11.00	15	5.28
	Time Point 3	7.80	15	4.89

PCL-5

The means and standard deviations for the scores for the PCL-5 at each time point is presented in Table 4 as the product of paired samples statistics, comparing the two points in time, for all participants. The sample size included in the comparison of means is the number of participants who completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). I also segmented and analyzed data by gender and individual cohorts. The distribution of responses by gender are shown in Tables 5 and 6. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 4

Descriptive Statistics for PCL-5 at Three Points in Time

Pair		*M*	*n*	*SD*
1	Time Point 1	44.82	22	13.77
	Time Point 2	27.86	22	13.81
2	Time Point 2	28.47	19	14.70
	Time Point 3	27.11	19	16.00
3	Time Point 1	43.35	20	12.55
	Time Point 3	28.30	20	15.65

Table 5

Descriptive Statistics for PCL-5 at Three Points in Time, Female Participants

Pair		*M*	*n*	*SD*
1	Time Point 1	51.14	7	13.51
	Time Point 2	26.71	7	11.13
2	Time Point 2	34.43	7	14.25
	Time Point 3	32.14	7	15.64
3	Time Point 1	51.33	6	6.77
	Time Point 3	37.17	6	12.64

Table 6

Descriptive Statistics for PCL-5 at Three Points in Time, Male Participants

Pair		*M*	*n*	*SD*
1	Time Point 1	41.87	15	13.30
	Time Point 2	28.40	15	15.24
2	Time Point 2	25.00	12	14.39
	Time Point 3	24.17	12	16.12
3	Time Point 1	39.93	14	13.06
	Time Point 3	24.50	14	15.64

GAD-7

The means and standard deviations of scores for the GAD-7 at each time point is presented in Table 7 as a product of paired samples statistics, comparing the points in time, for all participants. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All participants completed the ocean surf therapy program (n = 41), but not all participants answered the surveys at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where I compared the means and mean differences. I also segmented and analyzed data by gender and individual cohorts. The means, sample sizes, and standard deviations for gender are shown in Tables 8 and 9. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings. The paired samples *t* tests and related statistical significance calculations are discussed later in this chapter.

Table 7

Descriptive Statistics for GAD-7 at Three Points in Time

	Pair	*M*	*n*	*SD*
1	Time Point 1	12.44	16	5.49
	Time Point 2	5.06	16	3.94
2	Time Point 2	6.46	13	5.50
	Time Point 3	7.77	13	5.96
3	Time Point 1	11.59	17	5.09
	Time Point 3	8.06	17	4.85

Table 8

Descriptive Statistics for GAD-7 at Three Points in Time, Female Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	13.00	3	4.36
	Time Point 2	6.00	3	4.00
2	Time Point 2	9.75	4	8.18
	Time Point 3	12.00	4	6.22
3	Time Point 1	13.00	5	3.39
	Time Point 3	8.80	5	2.86

Table 9

Descriptive Statistics for GAD-7 at Three Points in Time, Male Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	12.31	13	5.86
	Time Point 2	4.85	13	4.06
2	Time Point 2	5.00	9	3.54
	Time Point 3	5.89	9	5.09
3	Time Point 1	11.00	12	5.67
	Time Point 3	7.75	12	5.56

Physiological Biomarkers Via Whoop

First, I exported data from Whoop as a comma separated values (i.e., .csv) file, then converted them to Excel to generate the heart rate variability (HRV), resting heart rate (RHR), rapid eye movement (REM) sleep, and deep sleep scores for each subject. I contacted a total of 33 individuals for Whoop band participation. Due to a supply chain issue during the study, Whoop bands were not available for one of the cohorts during 2021, and one of the cohorts had seven of eight participants in active-duty armed forces; thus, these individuals were not included in the study. Next, I imported data into SPSS 28 for summary statistic generation, assumption testing, and statistical analysis.

HRV

The means and standard deviations of scores for HRV at each time point is presented in Table 10 as a product of paired samples statistics, comparing the points in time. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All participants completed the ocean surf therapy program (n = 33), but not all participants recorded data at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where I compared the means and mean differences. I also segmented and analyzed data by gender and individual cohorts. The means, sample sizes, and standard deviations for gender are shown in Tables 11 and 12. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 10

Descriptive Statistics for HRV at Three Points in Time

Pair		*M*	*n*	*SD*
1	Time Point 1	41.94	26	27.90
	Time Point 2	37.05	26	23.22
2	Time Point 2	36.88	28	22.66
	Time Point 3	39.31	28	20.84
3	Time Point 1	41.94	26	27.90
	Time Point 3	40.39	26	21.25

Table 11

Descriptive Statistics for HRV at Three Points in Time, Female Participants

Pair		*M*	*n*	*SD*
1	Time Point 1	31.02	9	13.68
	Time Point 2	27.25	9	12.35
2	Time Point 2	29.38	10	13.44
	Time Point 3	30.43	10	10.06
3	Time Point 1	31.02	9	13.68
	Time Point 3	30.70	9	10.63

Table 12

Descriptive Statistics for HRV at Three Points in Time, Male Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	47.72	17	31.95
	Time Point 2	42.24	17	26.15
2	Time Point 2	41.06	18	25.86
	Time Point 3	44.24	18	23.75
3	Time Point 1	47.72	17	31.95
	Time Point 3	45.51	17	23.84

RHR

The means and standard deviations of scores for RHR at each time point are presented in Table 13 as a product of paired samples statistics, comparing the points in time, for all participants. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All participants completed the ocean surf therapy program ($n = 33$), but not all participants recorded data at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where I compared the means and mean differences. The sample sizes for all participants are listed as a column in Table 13. I also segmented and analyzed data by gender and individual cohorts. The means, sample sizes, and standard deviations for gender are shown in Tables 14 and 15. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 13

Descriptive Statistics for RHR at Three Points in Time

	Pair	*M*	*n*	*SD*
1	Time Point 1	64.68	26	9.38
	Time Point 2	67.44	26	9.57
2	Time Point 2	66.39	29	9.61
	Time Point 3	64.79	29	9.22
3	Time Point 1	64.68	26	9.38
	Time Point 3	64.99	26	9.27

Table 14

Descriptive Statistics for RHR at Three Points in Time, Female Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	69.00	9	10.88
	Time Point 2	72.90	9	11.77
2	Time Point 2	71.46	10	11.99
	Time Point 3	69.79	10	11.08
3	Time Point 1	69.00	9	10.88
	Time Point 3	69.22	9	11.59

Table 15

Descriptive Statistics for RHR at Three Points in Time, Male Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	62.39	17	7.89
	Time Point 2	64.54	17	6.95
2	Time Point 2	63.71	19	7.06
	Time Point 3	62.16	19	7.03
3	Time Point 1	62.39	17	7.89
	Time Point 3	62.76	17	7.19

Deep Sleep

The means and standard deviations of scores for deep sleep at each time point are presented in Table 16 as a product of paired samples statistics, comparing the points in time. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All participants completed the ocean surf therapy program (n = 33), but not all participants recorded data at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where I compared the means and mean differences. The sample sizes are listed as a column in Table 16. I also segmented and analyzed data by gender and individual cohorts. The means, sample sizes, and standard deviations for gender are shown in Tables 17 and 18. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 16

Descriptive Statistics for Deep Sleep at Three Points in Time

Pair		*M*	*n*	*SD*
1	Time Point 1	1.27	26	0.44
	Time Point 2	1.39	26	0.40
2	Time Point 2	1.37	29	0.39
	Time Point 3	1.28	29	0.33
3	Time Point 1	1.27	26	0.44
	Time Point 3	1.29	26	0.34

Table 17

Descriptive Statistics for Deep Sleep at Three Points in Time, Female Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	1.16	9	0.56
	Time Point 2	1.47	9	0.41
2	Time Point 2	1.43	10	0.41
	Time Point 3	1.22	10	0.41
3	Time Point 1	1.16	9	0.56
	Time Point 3	1.24	9	0.43

Table 18

Descriptive Statistics for Deep Sleep at Three Points in Time, Male Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	1.32	17	0.37
	Time Point 2	1.35	17	0.40
2	Time Point 2	1.35	19	0.38
	Time Point 3	1.31	19	0.28
3	Time Point 1	1.32	17	0.37
	Time Point 3	1.32	17	0.30

REM Sleep

The means and standard deviations of scores for REM sleep at each time point are presented in Table 19 as a product of paired samples statistics, comparing the points in time. The sample size included in the comparison of means for each paired samples *t* test is where participants completed the survey for each time point in the comparison (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3). All participants completed the ocean surf therapy program ($n = 33$), but not all participants recorded data at every point in time. This factor explains the different sample sizes used in the paired samples *t* tests where I compared the means and mean differences. The sample sizes are listed as a column in Table 19. I also segmented and analyzed data by gender and individual cohorts. The means, sample sizes, and standard deviations for gender are shown in Tables 20 and 21. Cohorts are only discussed in this chapter when the analysis produced statistically significant findings.

Table 19

Descriptive Statistics for REM Sleep at Three Points in Time

	Pair	*M*	*n*	*SD*
1	Time Point 1	1.48	25	0.44
	Time Point 2	1.59	25	0.51
2	Time Point 2	1.56	29	0.53
	Time Point 3	1.37	29	0.47
3	Time Point 1	1.48	25	0.44
	Time Point 3	1.46	25	0.41

Table 20

Descriptive Statistics for REM Sleep at Three Points in Time, Female Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	1.49	8	0.35
	Time Point 2	1.75	8	0.46
2	Time Point 2	1.70	10	0.55
	Time Point 3	1.40	10	0.44
3	Time Point 1	1.49	8	0.35
	Time Point 3	1.50	8	0.42

Table 21

Descriptive Statistics for REM Sleep at Three Points in Time, Male Participants

	Pair	*M*	*n*	*SD*
1	Time Point 1	1.47	17	0.49
	Time Point 2	1.52	17	0.54
2	Time Point 2	1.49	19	0.51
	Time Point 3	1.35	19	0.49
3	Time Point 1	1.47	17	0.49
	Time Point 3	1.44	17	0.42

Data Analysis Procedures

In this section, I describe the data analysis procedures for both quantitative and qualitative data collected throughout the study. The quantitative data included survey data and physiological biomarker data. I analyzed all data captured from all participants. The quantitative data were subjected to computer analysis conducted in SPSS 28. As output from SPSS analysis, I collated the data in the form of tables, graphs, and figures to make the data presentation meaningful. The qualitative data analysis procedures, including the practical steps involved in the analysis, are also discussed in this section.

Surveys

I conducted paired samples *t* tests for PCL-5 scores, GAD-7 scores, and PHQ-8 scores using the time point of the survey as the independent variable. First, I tested the assumptions underlying the use of paired samples *t* tests. Specifically, the first assumption required the dependent variable be continuous in nature. This assumption was met for all dependent variables (i.e., PCL-5, GAD-7, and PHQ-8 scores) because all dependent variables were measured as aggregate scales. The second assumption required the independent variable in a paired samples *t* test be a marker that denotes how subjects have been measured in two or more time points on the same dependent variable. This assumption was met because subjects were measured before participating in the ocean surf therapy event (i.e., Time Point 1), immediately after the event (i.e., Time Point 2), and 30 days after the event (i.e., Time Point 3).

PCL-5

The PCL-5 is a 20-item self-report measure of the 20 DSM-5 symptoms of PTSD (Bovin et al., 2016). As discussed in Chapter 3, this survey uses a 5-point Likert scale, with the values 0 to 4, for a total score of 80. Consistent with the Likert scale, a score of 0 indicates *not at all*, a score of 1 indicates *a little bit*, a score of 2 indicates *moderately*, a score of 3 indicates *quite a bit*, and a score of 4 indicates *extremely*. There are two scoring methodologies for symptom severity. A total score of 31 is the cutoff score used to indicate probable PTSD. There is also a diagnostic classification scoring method (Cohen et al., 2014). Included in the scale are four domains consistent with the four criteria of PTSD in DSM-5: reexperiencing (i.e., criterion B), avoidance (i.e., criterion C), negative alterations in cognition and mood (i.e., criterion D), and hyperarousal (i.e., criterion E). The PCL-5 measures the presence and severity of PTSD symptoms. For the diagnostic scoring, an answer of 2 (i.e., *moderate*), on a combination including at least one question from cluster B (i.e., Questions 1–5), one question from cluster C (i.e., Questions 6 and 7), two questions from cluster D (i.e., Questions 8–14), and two questions from cluster E (i.e., Questions 15–20) indicates probable PTSD. Evidence for the PCL for DSM-5 suggests a 5–10-point change represents reliable change (i.e., change not due to chance) and a 10–20-point change represents clinically meaningful change. According to the U.S. Department of Veteran's Affairs (VA), change scores for the PCL-5 were being determined at the time of analysis (Weathers et al., 2013). It was expected that reliable and clinically meaningful change will be in a similar range, and it was recommended by the VA to follow the DSM-4 recommendations until new information is available (VA, n.d.-b).

GAD-7

GAD is considered one of the most common mental disorders, and the popular seven-item GAD-7 measures the severity of anxiety. Originally created by Spitzer et al. (2006), the seven-item anxiety scale has strong reliability (A = .92) and criterion, construct, factorial, and procedural validity. The seven-question survey is scored by assigning scores of 0, 1, 2, and 3 to the response categories of *not at all*, *several days*, *more than half the days*, and *nearly every day*. When the scores are added up, they result in a total score of between 0 and 21, with higher scores associated with greater anxiety. The total scores can then be interpreted using the following scale: (a) 0–4 indicates minimal anxiety, (b) 5–9 indicates mild anxiety, (c) 10–14 indicates moderate anxiety, and (d) 15–21 indicates severe anxiety.

PHQ-8

Spitzer et al. (1994) developed and validated the Primary Care Evaluation of Mental Disorders (PRIME-MD) in the early 1990s to efficiently diagnose five of the most common types of mental disorders: depression, anxiety, somatoform, alcohol disorders, and eating disorders. Building upon this instrument through two large studies enrolling 6,000 patients, Spitzer et al. (2000) developed and validated a self-administered version of the PRIME-MD called the PHQ. This PHQ-9 has been shown to be a reliable and valid measure of depression severity (Kroenke et al., 2001). The instrument used in this study, the PHQ-8, includes all items of the PHQ-9 but omits the ninth item, which queries about thoughts of death and self-harm and was viewed as inappropriate for this population. Fortunately, the PHQ-8 has been shown to be a valid diagnostic and severity measure for depressive disorders in large clinical studies (Kroenke et al., 2009).

The PHQ-8 is increasingly being used in research, with study results showing the PHQ-8 as slightly less sensitive and specificity within .01 for all cutoffs (Y. Wu et al., 2020). With the PHQ-8 and PHQ-9 showing similar scores in other studies, it was decided to omit the ninth question and use the PHQ-8 for this research study.

The eight-question PHQ-8 is scored by assigning scores of 0, 1, 2, and 3 to the response categories of *not at all*, *several days*, *more than half the days*, and *nearly every day*; when the scores are added up, they result in a total score of between 0 and 24, with higher scores associated with greater depression (Kroenke et al., 2001). A total score of 0–4 represents no significant depressive symptoms, 5–9 represents mild symptoms, 10–14 represents moderate symptoms, 15–19 represents moderately severe symptoms, and 20–24 represents severe symptoms. There is an additional ancillary scoring instruction where if a respondent gives a total score of 3 or higher on the first two questions, this suggests anxiety; if the respondent gives a total score of 3 or higher on the last two questions, this suggests depression (Kroenke et al., 2009).

Physiological Biomarkers

I conducted paired samples *t* tests for HRV, RHR, REM sleep, and deep sleep scores using the mean score for each of the three time points as the independent variable. The before data were collected up to 14 days prior, aggregated with a mean score, and served as Time Point 1. The 4 days during the event data were aggregated with a mean score and served as Time Point 2. Finally, the 30 days post event data were aggregated with a mean score and served as Time Point 3. These paired measurements represent a measurement taken at two different times related to participating in an Operation Surf event. For this analysis, I conducted a comparison of these means across the three separate pairs (i.e., Time Point 1 and Time Point 2, Time Point 2 and Time Point 3, and Time Point 1 and Time Point 3), which I also did with the survey data. I segmented data for analysis including all participants, by cohort, and by gender. I used paired samples *t* tests to compare the means of two measurements taken from the same individual while also providing statistical significance. Then, I used these data to quantify change in variables for the various data segments, both as a number and as a percentage of baseline, where applicable. I also examined data on an individual level, calculating minimums, maximums, means, and medians to build a robust analysis.

HRV

HRV is a measure of the fluctuation in length of time between successive heartbeats; its source originates in the nervous system and provides a valuable window into whole body functioning, with distinct information provided by measurements of RHR (Bilchick & Berger, 2006; Stauss, 2003). HRV is determined by the time between heart beats, known as RR intervals—which was named for the heartbeat's R phase, or the spikes seen on an electrocardiogram—measured in milliseconds (Whoop, 2021a). Whoop calculates HRV using the root mean square of successive differences between heartbeats (Shaffer & Ginsberg, 2017). Whoop also calculates HRV using a dynamic average combined with RHR each night while sleeping, focusing on the last slow wave sleep stage, or the period of deepest level of sleep. This calculation method enables an accurate understanding baseline from which to monitor trends and abnormalities. I used these data to calculate individual participants' data. Specifically, I aggregated individual scores and computed means.

RHR

RHR is also called basal heart rate and is a measure of the average heart beats per minute while the body is at rest in a neutral temperature environment and has not been subject to recent strain (Meserve, 2021). For most adults, the average RHR is between 60–100 beats per minute; average RHR generally increases with age, but there are many factors that can affect RHR (American Heart Association, n.d.). Whoop measures RHR each night using a dynamic average weighted toward the last period of slow wave sleep when the body is in its most restful state (Whoop, 2020b). This measurement enables users to get an accurate baseline from which to monitor trends and abnormalities. Then, I used these data to calculate individual participant's data sets for analysis. I aggregated individual scores and computed means to use for analysis.

REM Sleep

REM sleep is one of the four stages of sleep, along with light sleep, deep sleep, and awake, that make up the body's sleep cycles; REM sleep typically follows deep sleep and is the mentally restorative stage of sleep (Whoop, 2021b). During REM sleep, the brain converts short-term memories from that day to long-term memories. The brain is very active during this stage, which is when most dreams occur. Whoop monitors sleep in detail, monitoring how much sleep a participant gets, tracking and recording unobtrusively as they sleep. This calculation method enables an accurate baseline from which to monitor trends and abnormalities.

Deep Sleep

Deep sleep is one of the four stages of sleep and is known as the physically restorative stage of sleep (Whoop, 2020a). Whoop tracks the sleep spent in this stage each night, recording unobtrusively as participants sleep. This calculation method enables an accurate understanding baseline from which to monitor trends and abnormalities. I used these data to calculate each individual participant's data sets for analysis. Then, I aggregated individual scores and computed means to use for analysis.

Qualitative Analysis

Analysis transforms data into findings by bringing order, structure, and meaning to the mass of collected data (De Vos et al., 2005). According to De Vos et al. (2005):

> [The analytical process] does not proceed tidily or in a linear fashion but is more of a spiral process; it entails reducing the volume of the information, sorting out significant from irrelevant facts, identifying patterns and trends, and constructing a framework for communicating the essence of what was revealed by the data. (p. 333)

Qualitative data analysis for this study included data triangulation across several components gathered through a mini ethnographic study. I used field notes, journals of participant observations—both verbal and nonverbal—along with interviews, and GroupMe text message chats. I coded journals, participant observations, and GroupMe text message chats to enhance understanding and highlight key findings.

To code qualitative data, including the GroupMe text message chats, I used inductive coding, also called open coding, creating codes as they arose from the data set. I read and reread GroupMe chats along with field journals from the beach and from dinners in the evenings. As new data came in, I applied the codes from the previous texts and journals. When needed, I created new codes. Occasionally, I split a code into two or combined codes. The thematic analysis using the inductive coding was not only an iterative process, but it also gave me an unbiased and complete snapshot of the themes throughout the data. GroupMe text chats occurred for the group with greater frequency closer to their event; thus, I revisited those transcripts after every event. The coding process was ad hoc and ongoing through the entire study duration from

May 2021 through May 2022, helping me discover repeating themes and accomplish a winnowing of the data to reveal key insights using several sets of codes. I applied thematic analysis to the codes to further understanding and analyzed data according to the research questions.

Results

In this section, I discuss the results of this study in order of the research questions. This section begins with the quantitative survey data focused on depression, anxiety, and PTSD symptoms. Then, I discuss the quantitative physiological biomarker data and conclude with a discussion of the qualitative data.

Survey Results

The first research question and the associated null and alternate hypotheses were:

Research Question 1: To what extent, if any, is there a change in PTSD symptoms, depression, or anxiety among veterans who participate in Operation Surf as measured by the PCL-5, PHQ-8, and GAD-7 at three points in time?

$H_{0:}$ There is no change in PTSD symptoms, depression, or anxiety among veterans who participate in Operation Surf as measured by the PCL-5, PHQ-8, and GAD-7 at Time Point 1, Time Point 2, and Time Point 3.

H_1: There is a change in PTSD symptoms, depression, or anxiety among veterans who participate in Operation Surf as measured by the PCL-5, PHQ-8, and GAD-7 at Time Point 1, Time Point 2, and Time Point 3.

PHQ-8

I used the PHQ-8 survey scores as a measure of depression for this study. For all participants from May 2021 through May 2022, Time Point 1 had a mean of 11.12 when compared to Time Point 2, which was 6.18. The results indicate there was a paired difference mean reduction of 4.94 ($p \leq .01$) from Time Point 1 (i.e., before the event) to Time Point 2 (i.e., immediately after the event), indicating a 44% reduction in depression immediately after the event. Comparing the first and third time points, the mean score for Time Point 1 was 12.15 compared to an 8.50 mean score at Time Point 3. Scores of the paired differences between Time Point 1 and Time Point 3 had a mean reduction of 3.65 ($p \leq .01$), indicating a 30% depression reduction when scored 30 days after the event. The change between the second and third time points was not statistically significant.

Table 22

Descriptive Statistics for PHQ-8 at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	4.94	4.66	4.38	16	< .01
2	Time Point 2 – Time Point 3	-0.67	5.77	-0.49	17	.63
3	Time Point 1 – Time Point 3	3.65	5.32	3.07	19	< .01

Gender. I computed paired samples *t* tests for gender (i.e., male/female; see Table 23). For female participants, Time Point 1 had a mean of 12.50 and Time Point 2 had a mean of 6.25, which resulted in a paired difference mean of 6.25 ($p \leq .01$). This difference indicated a 50% reduction in depression immediately following the event. For the paired samples *t* test between Time Point 1 and Time Point 3, female participants scored 15.60 at Time Point 1 and 10.60 at Time Point 3, which resulted in a mean difference of 5.00 ($p \leq .05$). These results indicated a 32% reduction in depression 30 days following the event. The changes between the first and third time points were not statistically significant for female participants.

Table 23

Descriptive Statistics for PHQ-8 at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	6.25	0.96	13.06	3	< .01
2	Time Point 2 – Time Point 3	0.33	5.09	0.16	5	.88
3	Time Point 1 – Time Point 3	5.00	3.94	2.84	4	.05

For male participants, the PHQ-8 mean was 10.69 for Time Point 1 and 6.15 for Time Point 2 (see Table 24). These scores resulted in a paired difference mean of 4.54 ($p \leq .01$), indicating a 42% reduction in depression immediately following the event. Male participants scored 11.00 for Time Point 1 compared to 7.80 for Time Point 3. These scores resulted in a paired difference mean of 3.20 ($p \leq .05$), indicating a 29% reduction in depression 30 days following the event. The change between the second and third time points was not statistically significant for male participants.

Table 24

Descriptive Statistics for PHQ-8 at Three Points in Time, Male Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	4.54	5.29	3.10	12	< .01
2	Time Point 2 – Time Point 3	-1.17	6.24	-0.65	11	.53
3	Time Point 1 – Time Point 3	3.20	5.76	2.15	14	.05

Analysis by Cohort. I captured, aggregated, and analyzed scores using paired samples *t* tests for each cohort. There were six cohorts during the May 2021 through May 2022 time period, with each cohort including up to eight participants. Cohort 3 only included one veteran participant, so I did not conduct a cohort analysis on that cohort. Of all six cohorts, only Cohort 5 demonstrated statistically significant improvements during analysis. These data are shown in

Tables 25 and 26. Cohort 5 had a mean of 11.80 at Time Point 1 and a mean of 5.80 at Time Point 2, showing a paired difference mean of 6.00 ($p \leq .05$). These scores indicated a 51% reduction of depression immediately following the event. Cohort 5 showed a mean of 14.40 at Time Point 1 compared to a 7.20 mean at Time Point 3, resulting in a 7.20 paired difference mean ($p \leq .01$). This result indicated a 50% reduction of depression from before the event to 30 days following the event.

Table 25

Descriptive Statistics for PHQ-8 at Three Points in Time, Cohort 5

	Pair	*M*	*n*	*SD*
1	Time Point 1	11.80	5	4.87
	Time Point 2	5.80	5	4.76
2	Time Point 2	7.00	4	4.55
	Time Point 3	6.75	4	5.91
3	Time Point 1	14.40	5	5.13
	Time Point 3	7.20	5	5.22

Table 26

Paired Samples t *Test Statistics for PHQ-8 at Three Points in Time, Cohort 5*

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	6.00	3.94	3.41	4	.03
2	Time Point 2 – Time Point 3	0.25	4.27	0.12	3	.91
3	Time Point 1 – Time Point 3	7.20	2.59	6.22	4	< .01

Clinical Analysis. I asked 41 military veterans to participate in the PHQ-8 survey, and all 41 agreed. Of the 41 participants, 78% ($n = 32$) completed the survey at Time Point 1, 54% ($n = 22$) completed the survey at Time Point 2, and 63% ($n = 26$) completed the survey at Time Point 3. Using the previously discussed guidelines to determine depression severity of the participants, the following section outlines the results. In this section, I also present the analyses of the data on an individual basis and an aggregate score across the program and percentage change at the program level compared across the three points in time, for both the survey scores and the suggested anxiety and depression markers.

Two participants (6.25%) had the highest classification of severe depression (i.e., scoring between 20–24 out of a 24-point survey maximum) at Time Point 1. One participant out of 22 respondents (4.55%) had the highest classification of severe depression at Time Point 2, indicating a 1.70% reduction of participants with the highest classification of severe depression immediately following the event. One out of 26 (3.85%) participants had the highest classification of severe depression at Time Point 3, indicating a 2.4% reduction in the highest classification of severe depression 30 days following the ocean surf therapy event.

Fourteen participants (43.75%) had the second highest classification of moderately severe depression (i.e., 15–19 total score on a 24-point maximum) at Time Point 1. No participants had the second highest classification of moderately severe depression at Time Point 2, indicating a 43.75% reduction in moderately severe depression immediately following the ocean surf therapy event. Two participants out of 26 (7.69%) had the second highest classification of moderately severe at Time Point 3, indicating a 36.06% reduction in moderately severe depression when surveyed 30 days after the ocean surf therapy event compared to prior to the event.

Six of the participants who responded at Time Point 1 (18.75%, n = 32) scored moderate depression (i.e., 10–14 total score on a 24-point maximum). Six of the participants who responded at Time Point 2 (27.27%) scored moderate depression, and eight participants scored moderate depression at Time Point 3 (30.77%).

Seven of the participants who responded at Time Point 1 (21.88%, $n = 32$) scored mild depression (i.e., 5–9 total score on a 24-point maximum). Six of the participants who responded at Time Point 2 (27.27%, $n = 22$) scored mild depression, and seven participants who reported a score at Time Point 3 (26.92%, $n = 26$) showed mild depression.

Of the 22 participants who reported a survey score at Time Point 2, nine participants (40.91%), had a total score of 0 to 4, representing no significant depressive symptoms immediately following the event, compared to 3 participants (9.38%, $n = 32$) at Time Point 1, indicating 31.53% more participants had no significant depressive symptoms immediately following the event. Of the 26 participants who reported a survey score at Time Point 3, there were 8 participants (30.77%) who reported a total score of 0 to 4, representing no significant depressive symptoms at Time Point 3, indicating a 21.39% increase of participants scoring no depressive symptoms compared to only 9.38% who reported no depressive symptoms prior to the event.

Twenty out of 32 participants (62.50%) scored a 3 or higher on the first two questions at Time Point 1, suggesting they were experiencing anxiety. Four out of 26 participants (15.38%) scored a 3 or higher on the first two questions at Time Point 2, which was a 47.12% reduction in participants experiencing anxiety from Time Point 1. Seven out of 25 participants (28.00%) scored a 3 or higher on the first two questions at Time Point 3, which was a 34.50% reduction in participants experiencing anxiety 30 days after the event when compared to Time Point 1.

Seventeen out of 32 participants (53.13%) scored a 3 or higher on the last two questions of the PHQ-8, suggesting they were experiencing depression at Time Point 1. Six out of 26 participants (23.08%) scored a 3 or higher on the last two questions at Time Point 2, which was a 30.05% reduction of suggested depression immediately after the event when compared to Time

Point 1. Five out of 25 participants (20.00%) scored a 3 or higher on the last two questions at Time Point 3, which was a 33.13% reduction of suggested depression when surveyed 30 days after the event compared to Time Point 1.

PCL-5

Table 27 shows the results of the paired samples t tests for the PCL-5 measures, including computations of the paired differences for means, standard deviations, and significance two-sided p scores. As an aggregate group, including all participants from May 2021 through May 2022, Time Point 1 had a mean of 44.82 when compared to Time Point 2, which was 27.86. There was a paired difference mean reduction of 16.95 from Time Point 1 to Time Point 2 ($p \leq .01$), indicating a 38% reduction of PTSD symptoms immediately after the event. Time Point 1 had a score of 43.35 compared to 28.30 at Time Point 3. Scores of the paired differences between Time Point 1 and Time Point 3 had a mean reduction of 15.05 ($p \leq .01$), indicating a 35% reduction of PTSD symptoms when scored 30 days after the event.

Table 27

Descriptive Statistics for PCL-5 at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	16.95	14.17	5.61	21	< .01
2	Time Point 2 – Time Point 3	1.37	16.84	0.35	18	.73
3	Time Point 1 – Time Point 3	15.05	14.53	4.63	19	< .01

Gender. I computed paired samples t tests for female participants (see Table 28). The PCL-5 mean was 51.14 for Time Point 1 and 26.71 for Time Point 2, resulting in a paired difference mean of 24.43 ($p \leq .01$). This score indicated a 48% reduction of PTSD symptoms immediately following the event. The change between the second and third time points, and the first and third time points, were not statistically significant for female participants.

Table 28

Descriptive Statistics for PCL-5 at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	24.43	13.55	4.77	6	< .01
2	Time Point 2 – Time Point 3	2.29	22.43	0.27	6	.80
3	Time Point 1 – Time Point 3	14.17	15.48	2.24	5	.08

For male participants, Time Point 1 had a mean of 41.87 and Time Point 2 had a mean of 28.40, which resulted in a paired difference mean of 13.47 ($p \leq .01$; see Table 29). This score indicated a 32% reduction in PTSD symptoms immediately following the event. For the paired samples *t* test between Time Point 1 and Time Point 3, male participants scored 39.93 at Time Point 1 and 24.50 at Time Point 3, which resulted in a mean difference of 15.43 ($p \leq .01$). These results indicated a 39% reduction in PTSD symptoms 30 days following the event. The change between the second and third time points were not statistically significant for male participants.

Table 29

Descriptive Statistics for PCL-5 at Three Points in Time, Male Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	13.47	13.48	3.87	14	< .01
2	Time Point 2 – Time Point 3	0.83	13.74	0.21	11	.84
3	Time Point 1 – Time Point 3	15.43	14.70	3.93	13	< .01

Analysis by Cohort. I also captured, aggregated, and analyzed scores using paired samples *t* tests for each cohort. There were six cohorts during the May 2021 through May 2022 time period, with each cohort including up to eight participants. Cohort 3 only included one veteran participant, so I did not conduct a cohort analysis for that cohort. Of all the six cohorts, Cohorts 1, 2, and 5 demonstrated statistically significant improvements in one or more of their paired samples tests (see Tables 30–35). Cohort 1 had a mean of 40.80 at Time Point 1 and a score of 25.40 at Time Point 3, showing a paired difference mean of 15.40 ($p \leq .01$). This score indicated a reduction of 38% in PTSD symptoms when surveyed 30 days following the event. Cohort 2's mean score was 50.00 at Time Point 1 and 32.25 at Time Point 2, resulting in a 17.75 paired difference mean ($p \leq .01$). This result indicated a 36% reduction from before the event to 30 days following the event. Cohort 5 had a 42.33 mean at Time Point 1 compared to a 17.50 mean at Time Point 2, resulting in a 24.83 paired difference mean ($p \leq .01$). This result indicated a 59% reduction from before the event to 30 days following the event.

Table 30

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 1

Pair		*M*	*n*	*SD*
1	Time Point 1	41.00	3	21.93
	Time Point 2	17.67	3	10.97
2	Time Point 2	17.67	3	10.97
	Time Point 3	24.33	3	11.02
3	Time Point 1	40.80	5	15.71
	Time Point 3	25.40	5	8.20

Table 31

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 2

	Pair	*M*	*n*	*SD*
1	Time Point 1	50.00	4	10.61
	Time Point 2	32.25	4	13.00
2	Time Point 2	35.60	5	13.52
	Time Point 3	26.20	5	15.69
3	Time Point 1	50.00	4	10.61
	Time Point 3	28.75	4	16.88

Table 32

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 5

	Pair	*M*	*n*	*SD*
1	Time Point 1	42.33	6	10.71
	Time Point 2	17.50	6	12.49
2	Time Point 2	17.60	5	13.96
	Time Point 3	25.80	5	21.68
3	Time Point 1	46.00	5	6.52
	Time Point 3	25.80	5	21.68

Table 33

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 1

	Pair	SMD	SD	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	23.33	12.06	3.35	2	.08
2	Time Point 2 – Time Point 3	-6.67	5.13	-2.25	2	.15
3	Time Point 1 – Time Point 3	15.40	8.08	4.26	4	.01

Table 34

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 2

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	17.75	3.30	10.74	3	< .01
2	Time Point 2 – Time Point 3	9.40	20.85	1.01	4	.37
3	Time Point 1 – Time Point 3	21.25	18.87	2.25	3	.11

Table 35

Descriptive Statistics for PCL-5 at Three Points in Time, Cohort 5

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	24.83	14.08	4.32	5	< .01
2	Time Point 2 – Time Point 3	-8.20	10.08	-1.82	4	.14
3	Time Point 1 – Time Point 3	20.20	18.87	2.39	4	.07

Clinical Results. I asked 41 military veterans to participate in the PCL-5, and all 41 agreed. Of the 41 participants, 78% (n = 32) completed the survey at Time Point 1, only 56% (n = 23) completed the survey at Time Point 2, and 63% (n = 26) completed the survey at Time Point 3. Using the guidelines discussed previously in the data analysis section to determine probable PTSD of the participants, I outline the results of the data, including both clinical scoring methodologies, in this section. I overview the symptom severity measure and how I used the diagnostic data on an individual basis and used an aggregate score across the program and percentage change at the three points in time. In this section, I also examine scores to see if there was a 5–10-point change (i.e., reliable change) or a 10–20-point change (i.e., a clinically meaningful change).

Out of 32 participants, 25 had above a clinical threshold level of PTSD symptoms by severity measure (> 31) at Time Point 1, resulting in 78% of participants with probable PTSD. Using the symptom cluster approach at Time Point 1, 26 out of 32 participants scored an above clinical threshold level for PTSD symptoms, indicating 81% of participants had probable PTSD. However, 13 out of 26 participants (50%) had above a clinical threshold level of PTSD symptoms (> 31) at Time Point 2, which was a reduction in number of participants with PTSD symptoms of 28%. The number of participants with an above clinical threshold of PTSD symptoms using the symptom cluster approach at Time Point 2 was 16 out of 26 (61.54%), indicating a reduction in the number of participants with probable PTSD of 19.71% compared to Time Point 1. The number of participants scoring above a clinical threshold of PTSD symptoms (> 31) using symptom severity approach at Time Point 3 was 7 out of 23 (30.43%), which indicated a 48% reduction in the number of participants with probable PTSD compared to Time Point 1. The number of participants with an above clinical threshold of PTSD symptoms using the symptom cluster approach at Time Point 3 was 4 out of 23 (17.39%), which showed a 64% reduction in participants with probable PTSD compared to Time Point 1.

On an individual basis, of the 22 participants who completed the survey at both Time Point 1 and Time Point 2, 19 out of 22 saw a reduction in their severity score, resulting in 86.36% of the program participants showing a reduction in PTSD symptoms. For the comparison between Time Point 1 and Time Point 3, of which 21 people completed both surveys, 19 of those 21 (90.48%) showed a reduction in total overall score.

A total of 22 participants completed the PCL-5 survey at Time Point 1 and Time Point 2. One individual (4.55%) had a 5–10-point reliable reduction in total score from Time Point 1 to Time Point 2, and an additional 17 of the 22 (77.27%) had a 10–20-point clinically meaningful reduction in score from Time Point 1 to Time Point 2. Of the 41 total participants who were administered surveys, 21 completed the PCL-5 survey at Time Point 1 and Time Point 3. Two individuals (10%) had a 5–10-point meaningful reduction in total score and an additional 15 participants (71%) saw a 10–20-point clinically meaningful reduction in total score.

GAD-7

Table 36 shows results of the paired samples *t* tests for the GAD-7, including computations of paired differences for means, standard deviations, and significance two-sided *p* scores. As an aggregate group of all participants from May 2021 through May 2022, mean score at Time Point 1 was 12.44 and the mean score at Time Point 2 was 5.06. There was a paired difference mean reduction of 7.38 from Time Point 1 to Time Point 2 ($p \leq .01$), indicating a 59% reduction in general anxiety immediately after the event. When comparing the first and third time points, the mean at Time Point 1 was 11.59 compared to a mean of 8.06 at Time Point 3. Scores of the paired differences between Time Point 1 and Time Point 3 had a mean difference of 3.53 ($p \leq .05$), indicating a 30% reduction in general anxiety from before the event to 30 days after.

Table 36

Descriptive Statistics for GAD-7 at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	7.38	5.00	5.89	15	< .01
2	Time Point 2 – Time Point 3	-1.31	5.02	-0.94	12	.37
3	Time Point 1 – Time Point 3	3.53	6.49	2.24	16	.04

Gender. Results of the paired samples *t* tests for female participants are shown in Table 37. For female participants, the mean score on the GAD-7 was 13.00 for Time Point 1 and 6.00 for Time Point 2, resulting in a paired difference of 7.00 ($p \leq .05$). This score indicated a 54% reduction in general anxiety immediately following the event. The change between the second and third time points, and the first and third time points, were not statistically significant for female participants.

Table 37

Descriptive Statistics for GAD-7 at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	7.00	1.73	7.00	2	.02
2	Time Point 2 – Time Point 3	-2.25	4.57	-0.98	3	.40
3	Time Point 1 – Time Point 3	4.20	4.44	2.12	4	.10

For male participants, the Time Point 1 mean was 12.31 and Time Point 2 mean was 4.85, which resulted in a paired difference mean of 7.46 ($p \leq .01$). This score indicated a 61% reduction in general anxiety immediately following the event. The change between the second and third time points, and the first and third time points, were not statistically significant for male participants.

Table 38

Descriptive Statistics for GAD-7 at Three Points in Time, Male Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	7.46	5.55	4.85	12	< .01
2	Time Point 2 – Time Point 3	-0.89	5.42	-0.49	8	.64
3	Time Point 1 – Time Point 3	3.25	7.34	1.53	11	.15

Analysis by Cohort. I also captured, aggregated, and analyzed scores using paired samples *t* tests for each cohort. There were six cohorts during the May 2021 through May 2022 time period, with each cohort including up to eight participants. Cohort 3 only included one veteran participant, so I did not conduct a cohort analysis on that cohort. Of all six cohorts, only

Cohort 5 demonstrated statistically significant improvements in one of their paired samples *t* tests (see Tables 39 and 40). Cohort 5 had a mean of 12.60 at Time Point 1 and a mean of 2.80 at Time Point 2, showing a paired difference mean of 9.80 ($p \leq .05$). This score indicated a 78% reduction of general anxiety 30 days after the event compared to before the event.

Table 39

Descriptive Statistics for GAD-7 at Three Points in Time, Cohort 5

	Pair	*M*	*n*	*SD*
1	Time Point 1	12.60	5	5.50
	Time Point 2	2.80	5	1.92
2	Time Point 2	2.75	4	2.22
	Time Point 3	6.25	4	7.41
3	Time Point 1	12.20	5	5.54
	Time Point 3	6.00	5	6.44

Table 40

Paired Samples Statistics for GAD-7 at Three Points in Time, Cohort 5

	Pair	*SMD*	*SD*	*t*	*df*	Two-sided *p*
1	Time Point 1 – Time Point 2	9.80	5.54	3.95	4	.02
2	Time Point 2 – Time Point 3	-3.50	5.45	-1.29	3	.29
3	Time Point 1 – Time Point 3	6.20	6.50	2.13	4	.10

Clinical Analysis. For the GAD-7, I asked 41 military veterans to participate, and all 41 agreed. Of the 41 participants, 73% ($n = 30$) completed the survey at Time Point 1, 51% ($n = 21$) completed the survey at Time Point 2, and 51% ($n = 21$) completed the survey at Time Point 3. Using the aforementioned guidelines to determine the general anxiety severity of the participants, I outline the results in the following section. I also analyze the data on an individual basis and an aggregate score across the program and percentage change at the three points in time.

At Time Point 1, 12 of the 30 participants (40.00%) scored in the highest classification of severe anxiety (i.e., scoring between 15–21 on a 21-point maximum). At Time Point 2, two of the 21 participants (9.52%) scored in the highest classification of severe anxiety, indicating a 30.48% reduction in general anxiety immediately following the ocean surf therapy program. At Time Point 3, three of the 21 participants (14.29%) scored in the highest classification of severe anxiety, indicating a 25.71% reduction in general anxiety 30 days following the ocean surf therapy event when compared to Time Point 1.

Nine of the 30 participants (30.00%) scored in the next highest classification of moderate anxiety (i.e., scoring between 10–14 on a 21-point maximum) at Time Point 1. Three participants (14.29%) scored as having moderate anxiety at Time Point 2, indicating a 15.71% reduction in general anxiety immediately following the ocean therapy event. Four participants (19.05%) scored as having moderate anxiety at Time Point 3, indicating a 10.95% reduction in general anxiety 30 days after the event when compared to Time Point 1.

Survey Results Summary

The results of the paired samples *t* tests across the three time points and for all three surveys indicated statistically significant changes in depression, anxiety, and PTSD symptoms immediately following the ocean surf therapy event. Scores for anxiety, depression, and PTSD symptoms before the therapy, as measured by the PHQ-8, PCL-5, and GAD-7, were significantly higher than both time points after therapy. Based on these findings and the paired samples *t* test presented, results revealed a significant decrease in anxiety, depression, and PTSD symptoms for military veterans following ocean surf therapy. Based on these findings and the paired samples *t* tests, the null hypothesis is rejected because there was a change.

Physiological Biomarkers Via Whoop

In this section, I present the results associated with the physiological data, which includes HRV, RHR, REM sleep, and deep sleep. For these chosen physiological biomarkers, the data points I used in analysis included the minimum scores, maximum scores, and means. I segmented data used for analysis from individual participants of the Operation Surf ocean therapy program.

The second research question and the associated null and alternate hypotheses were:

Research Question 2: To what extent, if any, is there a change in physiological biomarker data among veterans who participate in Operation Surf?

H_0: There is no change in physiological biomarker data among veterans who participate in Operation Surf as measured by HRV, RHR, REM sleep, and deep sleep.

H_1: There is change in physiological biomarker data among veterans who participate in Operation Surf as measured by HRV, RHR, REM sleep, and deep sleep.

The paired samples *t* test to evaluate for differences between paired measurements for this Research Question met all assumptions necessary (i.e., subjects were independent, measurements for one subject did not affect measurement for any other subject, each of the paired measurements were obtained from the same subject, and measured differences were normally distributed).

I collected physiological biomarker data through Whoop bands, which was a piece of wearable technology hardware typically worn slightly above the wrist. Participants wore the

Whoop bands up to 14 days prior to participating in the Operation Surf event, during the 4-day event, and for a period of 30 days following the event. Then, I exported data from all participants from Whoop via a common separated value (i.e., .csv) file. Next, I opened the file in Excel to generate data set scores for each subject. I contacted a total of 33 veterans for participation in this data collection effort, and all 33 agreed to participate. The slightly lower number of Whoop band wearers compared to the survey participants ($n = 41$) was due to a supply chain issue with Whoop straps; Whoop was unable to fulfill the November 2021 order for hardware. Fortunately, the supply chain issue was resolved for 2022.

I performed analysis across the data set in several ways. First, I segmented the data into three groups of time: before the event, during the event, and post event. The days before the event, up to 14 in total, were grouped together to form Time Point 1. The days during the 4-day ocean surf therapy event were grouped together to form Time Point 2. I chose 30 days following the event as the time period for the after event analysis, which was in line with the time period of the survey data at Time Point 3. Once the data were segmented according to time period, I calculated the mean, median, maximum, and minimum scores for each grouping. Then, I imported data into SPSS 28 for summary statistic generation, assumption testing, and statistical analysis. For determining statistical significance, I compared and analyzed scores using paired samples *t* tests to compare the score for each subject across the three points in time. The paired samples *t* tests compared the means of the measurements taken across the three points in time (i.e., before the event, during the event, and 30 days following the event) taken from the same individual because physiological biomarker data is unique for each individual. Next, I compared the means using paired samples *t* tests in SPSS to calculate mean differences, standard deviations, and statistical significance. Following statistical analysis and comparative mean examination of the groupings by time period, I also analyzed data at an individual level.

HRV

Table 41 shows the results of the paired samples *t* tests for HRV, including computations of the paired differences for means, standard deviations, and significant two-sided *p* scores. As an aggregate group of all participants from May 2021 through May 2022, only the Pair 1 comparison between Time Point 1 and Time Point 2 showed a statistically significant computation ($p \leq .05$). The Pair 1 comparison of HRV had a Time Point 1 mean of 41.94 and a Time Point 2 mean of 37.05, which was a paired mean difference of 4.89. This score indicated an HRV decrease of 12% during the event. The Pair 2 comparison of HRV at Time Point 2 (i.e., 36.88) and Time Point 3 (39.31) was a 2.42 paired mean difference. This score indicated HRV after the event increased 7%, but this difference was not statistically significant ($p = .11$). The change between the first and third time points was not statistically significant.

Table 41

Paired Samples Statistics for HRV at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	4.89	10.48	2.38	25	.03
2	Time Point 2 - Time Point 3	-2.42	7.71	-1.66	27	.11
3	Time Point 1 - Time Point 3	-1.56	12.00	-0.66	25	.51

Gender. Analysis of the HRV data segmented by gender did not reveal any statistically significant results. As such, the relevant tables are not discussed further in this chapter.

Analysis by Cohort. I also captured, aggregated, and analyzed HRV scores using paired samples *t* tests for each cohort. Excluding the single individual cohort, there were five potential cohorts for analysis. Only Cohort 2 demonstrated statistically significant improvements in two of the paired samples *t* tests (see Tables 42 and Table 43). Cohort 2 had a mean of 35.06 at Time Point 1 and a mean score of 27.43 at Time Point 2, showing a paired difference mean of 7.63 ($p \leq .01$). This score indicated HRV was 22% higher before the event than during the ocean surf therapy event. The Pair 2 comparison between Time Point 2 and Time Point 3 was also statistically significant ($p \leq .05$). The mean for Time Point 2 was 26.63 and the mean for Time Point 3 was 33.87, which was a paired difference of 7.24, indicating a 27% increase in HRV 30 days following the event.

Table 42

Descriptive Statistics for HRV at Three Points in Time, Cohort 2

Pair		*M*	*n*	*SD*
1	Time Point 1	35.06	7	11.31
	Time Point 2	27.43	7	11.37
2	Time Point 2	26.63	8	10.77
	Time Point 3	33.87	8	13.76
3	Time Point 1	35.06	7	11.31
	Time Point 3	35.49	7	14.02

Table 43

Paired Samples Statistics for HRV at Three Points in Time, Cohort 2

Pair		*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 – Time Point 2	7.63	4.92	4.10	6	< .01
2	Time Point 2 – Time Point 3	-7.24	6.45	-3.18	7	.02
3	Time Point 1 – Time Point 3	-0.43	8.95	-0.13	6	.90

Statistical Summary. The paired samples *t* tests showed a statistically significant difference in HRV for all participants when comparing the Time Point 1 means to Time Point 2 means, ($p \leq .05$), resulting in a 12% HRV decrease during the event ($n = 28$). The HRV mean for all participants at Time Point 2 compared to Time Point 3 was not statistically significant, ($p = .11$) but was 7% higher 30 days after the event when looking at the group in aggregate ($n = 28$).

When segmenting by individual cohorts, only Cohort 2 showed any paired mean calculations with statistical significance, with pair 1, Time Point 1 ($M = 35.06$) and Time Point 2 ($M = 27.43$), with a paired mean difference of 7.63, ($p \leq .01$), indicating HRV fell 22% during the event. Pair 2 showed a mean difference of -7.25 between Time Point 2 and Time Point 3, ($p \leq .05$), with a mean of 26.63 for Time Point 2 and 33.87 for Time Point 3 ($n = 8$). This score resulted in a 27% increase in HRV for the 30 days following the event.

Individual Participant Analysis and Results. I also analyzed data by individual persons for participants who had data available for at least two time points. Of the 28 individuals, analysis for Time Point 2 and Time Point 3 ($n = 28$), 23 (82%) had an increased HRV mean for Time Point 3. When comparing the Time Point 3 means individually to the Time Point 1 means ($n = 26$), 17 individuals (65%) had an increased HRV mean after the event compared to prior to the event.

Next, I analyzed data by gender across the three time points. For male participants ($n = 18$), 14 of individual participants (78%) had a higher HRV mean for Time Point 3 compared to Time Point 2. For female participants, 7 of the 10 (70%) individual participants who reported scores at Time Point 3 and Time Point 2 had a higher HRV. For females, the comparison between Time Point 3 and Time Point 1 before the event, 6 of individual participants (67%) had a higher HRV in the 30 days following the event compared to prior to the event ($n = 9$).

RHR

Table 44 shows the results of the paired samples *t* tests for RHR, including computations of the paired differences for means, standard deviations, and significant two-sided *p* scores. As an aggregate group of all participants from May 2021 through May 2022, only the comparison between Time Point 1 and Time Point 2 showed a statistically significant computation ($p \leq .01$). For all participants ($n = 26$), the Pair 1 comparison was a 64.68 mean before the event and a 67.44 during the event. This comparison shows RHR increased 4% during the event, with a paired mean difference of 2.76. The changes between the second and third time points, and the first and third time points, were not statistically significant.

Table 44

Descriptive Statistics for RHR at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-2.76	3.92	-3.58	25	< .01
2	Time Point 2 - Time Point 3	1.60	5.09	1.69	28	.10
3	Time Point 1 - Time Point 3	-0.31	3.44	-0.46	25	.65

Gender. Table 45 shows the results of the paired samples *t* test for female participants, including the paired differences for means, standard deviations, and two-sided *p* scores. For female participants, the only statistically significant comparison was Pair 1 between Time Point 1 and Time Point 2 ($p \leq .01$). Time Point 1 had a mean score of 69.00 and Time Point 2 had a mean score of 72.90, resulting in paired mean difference of 3.90. This score indicated RHR increased 6% for female participants during the event. The changes between the second and third time points, and the first and third time points, were not statistically significant.

Table 45

Descriptive Statistics for RHR at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-3.90	3.67	-3.18	8	.01
2	Time Point 2 - Time Point 3	1.66	7.50	0.70	9	.50
3	Time Point 1 - Time Point 3	-0.21	3.97	-0.16	8	.88

Table 46 shows the results of the paired samples *t* tests for male participants, including the paired differences for means, standard deviations, and two-sided *p* scores. For male participants, the only statistically significant comparison was Pair 1 between Time Point 1 and Time Point 2 ($p \leq .05$). The mean of Time Point 1 was 62.39 and the mean of Time Point 2 was 64.54, resulting in a paired mean difference of 2.15. This score indicated RHR increased 3% during the event. The changes between the second and third time points, and the first and third time points, were not statistically significant.

Table 46

Descriptive Statistics for RHR at Three Points in Time, Male Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-2.15	4.02	-2.21	16	.04
2	Time Point 2 - Time Point 3	1.56	3.50	1.94	18	.07
3	Time Point 1 - Time Point 3	-0.36	3.25	-0.46	16	.65

Analysis by Cohort. I also captured, aggregated, and analyzed RHR scores using paired samples *t* tests for each cohort. Of the six cohorts, only Cohort 2 demonstrated statistically significant changes in two of the paired samples *t* tests (see Tables 47 and 48). Cohort 2 had a mean of 65.25 at Time Point 1 and a mean of 70.11 at Time Point 2, showing a paired difference mean of 4.86, ($p \leq .05$). This score indicated RHR increased 7% for Cohort 2 during the event.

Cohort 2 had a mean of 68.76 at Time Point 2 and a mean of 64.68 at Time Point 3, showing a paired mean difference of 4.08, ($p \leq .05$). This score indicated RHR decreased 6% for Time Point 3, 30 days after the event, compared to during the event. The changes between the first and third time points were not statistically significant.

Table 47

Descriptive Statistics for RHR at Three Points in Time, Cohort 2

	Pair	*M*	*n*	*SD*
1	Time Point 1	65.25	7	9.49
	Time Point 2	70.11	7	11.34
2	Time Point 2	68.76	8	11.17
	Time Point 3	64.68	8	10.85
3	Time Point 1	65.25	7	9.49
	Time Point 3	65.99	7	11.01

Table 48

Paired Samples Statistics for RHR at Three Points in Time, Cohort 2

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-4.86	4.05	-3.17	6	.02
2	Time Point 2 - Time Point 3	4.08	4.42	2.62	7	.03
3	Time Point 1 - Time Point 3	-0.74	4.94	-0.39	6	.71

Statistical Summary. The paired samples t tests for RHR for all participants showed a statistically significant change only when comparing Time Point 1 means to Time Point 2 means, resulting in a 4% increase in RHR during the event ($p \leq .01$). When analyzing the data by gender, female participants showed an increase of 6% in RHR at Time Point 2 compared to Time Point 1

($p \leq .01$). For male participants, RHR was up 3% at Time Point 2 compared to Time Point 3 ($p \leq .05$).

When analyzing the data by cohorts, only Cohort 2 showed any statistically significant changes in RHR. The Time Point 1 mean was 7% lower than the Time Point 2 mean, while the Time Point 3 mean increased 6% compared to the Time Point 2 mean.

Deep Sleep

Table 49 shows the results of the paired samples *t* tests for deep sleep, including computations of the paired differences for means, standard deviations, and significant two-sided *p* scores. As an aggregate group of all participants from May 2021 through May 2022, only the Pair 2 comparison between Time Point 2 and Time Point 3 showed a statistically significant computation ($p \leq .05$). Pair 2 for deep sleep had a Time Point 2 mean hours of deep sleep of 1.37 and a Time Point 3 mean of 1.28, which shows a paired mean difference of .09, indicating deep sleep fell 7% in the 30 days following the event compared to during the event. The change between the first and second time points, and the first and third time points, were not statistically significant.

Table 49

Paired Samples Statistics for Deep Sleep at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-0.12	0.36	-1.74	25	.10
2	Time Point 2 - Time Point 3	0.09	0.23	2.14	28	.04
3	Time Point 1 - Time Point 3	-0.03	0.26	-0.50	25	.62

Gender. Paired samples *t*-test results for deep sleep for female participants are shown in Table 50. Time Point 1 had a mean deep sleep score of 1.16 hours and Time Point 2 had a mean deep sleep score of 1.47 hours, for a paired difference mean of .31 ($p \leq .05$). This score indicated a 27% increase in deep sleep during the event compared to prior to the event. Additionally, Pair 2, Time Point 2 had a mean of 1.43 and Time Point 3 had a mean of 1.22 ($p \leq .05$). This score resulted in a paired mean difference of .21, indicating deep sleep fell 15% for Time Point 3 when compared to during the event. The change between the first and third time points was not statistically significant.

Table 50

Descriptive Statistics for Deep Sleep at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-0.31	0.32	-2.89	8	.02
2	Time Point 2 - Time Point 3	0.21	0.24	2.70	9	.03
3	Time Point 1 - Time Point 3	-0.08	0.33	-0.71	8	.50

Analysis of the data for deep sleep for male participants did not reveal any statistically significant changes. Because there were no statistically significant results, the data are not discussed further in this chapter.

Analysis by Cohort. I also captured, aggregated, and analyzed deep sleep scores using paired samples *t* tests for each cohort. There were six cohorts during the May 2021 through May 2022 time period, with each cohort including up to eight participants. Of the six cohorts, none of the cohorts demonstrated statistically significant changes in the paired samples tests for deep sleep when analyzed by cohort. Because there were no statistically significant results, the data are not discussed further in this chapter.

Statistical Summary. The paired samples *t* tests detailed previously showed statistically significant changes in deep sleep for all participants only when comparing the Pair 2 paired samples *t* test (i.e., Time Point 2 to Time Point 3). In this comparison, deep sleep scores fell 7% during Time Point 3 when compared to Time Point 2 during the event ($p \leq .05$). When analyzing the data by gender, female participant scores were statistically significant when comparing Pair 1 (i.e., Time Point 1 and Time Point 2) and Pair 2 (i.e., Time Point 2 and Time Point 3). In the Pair 1 comparison, deep sleep increased 27% during the event compared to prior the event ($p \leq .05$). Female participants also had a statistically significant change in the Pair 2 *t* test, which resulted in a 15% decrease in deep sleep at Time Point 3 compared to Time Point 2 ($p \leq .05$).

REM Sleep

Table 51 shows the results of the paired samples *t* tests for REM sleep, including computations of the paired differences for means, standard deviations, and significant two-sided *p* scores. As an aggregate group of all participants from May 2021 through May 2022, there were no statistically significant results. REM sleep increased during Time Point 2 compared to Time Point 1 and Time Point 3, but not in a statistically significant manner. Time Point 2 (1.56) during the event was 13% higher in REM sleep compared to Time Point 3 ($p < .06$).

Table 51

Descriptive Statistics for REM Sleep at Three Points in Time

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-0.12	0.38	-1.50	24	.15
2	Time Point 2 - Time Point 3	0.20	0.54	1.96	28	.06
3	Time Point 1 - Time Point 3	0.02	0.42	0.21	24	.83

Gender. I computed paired samples *t* tests for REM sleep for female participants (see Table 52). For female participants, REM sleep had a mean of 1.70 hours at Time Point 2 and a mean of 1.40 hours for Time Point 3. These scores resulted in a paired difference mean of .30

hours, which was statistically significant ($p \leq .05$). This score indicated an 18% decrease in REM sleep at Time Point 3 for the 30 days after the event. The change between the first and second time points, and the first and third time points, were not statistically significant for female participants. Analysis of male participants did not reveal any statistically significant changes; thus, these data are not discussed.

Table 52

Descriptive Statistics for REM Sleep at Three Points in Time, Female Participants

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided p
1	Time Point 1 - Time Point 2	-0.26	0.36	-2.03	7	.08
2	Time Point 2 - Time Point 3	0.30	0.42	2.22	9	.05
3	Time Point 1 - Time Point 3	-0.01	0.42	-0.06	7	.96

Analysis by Cohort. I also captured, aggregated, and analyzed the REM sleep scores using paired samples *t* tests for each cohort. There were six cohorts during the May 2021 through May 2022 time period, but only Cohort 5 demonstrated statistically significant changes in Pair 2 of the paired samples *t* tests (see Tables 53 and 54). Cohort 5 had a mean of 1.81 at Time Point 2 and a mean of 1.41 at Time Point 3, revealing a paired difference mean of 0.40, which was statistically significant ($p \leq .05$). This score indicated REM sleep fell 22% in the 30 days after the event compared to during the event. The change between the first and second time points, and the first and third time points, were not statistically significant for Cohort 5.

Table 53

Descriptive Statistics for REM Sleep at Three Points in Time, Cohort 5

	Pair	M	*n*	*SD*
1	Time Point 1	1.54	7	0.44
	Time Point 2	1.81	7	0.26
2	Time Point 2	1.81	7	0.26
	Time Point 3	1.41	7	0.30
3	Time Point 1	1.54	7	0.44
	Time Point 3	1.41	7	0.30

Table 54

Paired Samples Statistics for REM Sleep at Three Points in Time, Cohort 5

	Pair	*SMD*	*SD*	*t*	*df*	Two-Sided *p*
1	Time Point 1 - Time Point 2	-0.27	0.31	-2.32	6	.06
2	Time Point 2 - Time Point 3	0.40	0.33	3.22	6	.02
3	Time Point 1 - Time Point 3	0.13	0.32	1.09	6	.32

Statistical Summary. The paired samples *t* tests showed REM sleep for all participants did not have any statistically significant changes. However, the Time Point 2 mean was 13% higher than the Time Point 3 mean ($p = .06$), meaning hours of REM sleep were higher during the event than 30 days afterward, but not statistically significant using the parameters determined ahead of analysis by the team ($p \leq .05$). When analyzing data by cohorts, only Cohort 5 showed any statistically significant change. The paired samples *t* test of Time Point 2 compared to Time Point 3 showed hours of REM sleep fell 22% for the 30 days following the event ($p \leq .05$). The female participants' paired *t* tests resulted in one paired sample with statistical significance (*p*

$\leq .05$); thus, REM sleep hours fell 18% for the 30 days following the event at Time Point 3 when compared to Time Point 2 during the event.

Physiological Biomarker Summary

The results of the paired samples *t* tests across the three time points for physiological biomarkers indicated varying degrees of statistically significant change in HRV, RHR, REM sleep, and deep sleep. Specifically, HRV decreased 12% during the event ($p \leq .05$), while increasing 7% in the 30 days following the event; however, these results were not statistically significant ($p = .11$) when using a paired samples *t* test to compare means to analyze for the pair group comparison of all participants ($n = 28$). However, for the group as a whole, HRV minimum, maximum, mean, and median were all higher for Time Point 3, 30 days after the event. At an individual level analysis, 82% of participants saw an increase in their HRV mean for the 30 days after the event compared to during the event, and 65% of participants saw their HRV mean increase 30 days after the event compared to before the event. REM sleep was 13% higher during the event compared to 30 days after the event ($n = 29$) but was not statistically significant ($p = .06$) for all participants. For female participants, REM sleep fell 18% ($n = 10$) in the 30 days after the event ($p \leq .05$) compared to during the event. Deep sleep increased 7% during the event for all participants ($p \leq .05$), with female participants showing a 27% increase in deep sleep during the event ($p \leq .05$) compared to before the event.

Using HRV, RHR, REM sleep, and deep sleep for analysis demonstrated statistically significant findings for changes in physiological biomarkers across the three time points. Based on these findings and the paired samples *t* tests, there was a change in physiological biomarkers following ocean surf therapy for military veterans; however, more research is needed, specifically with a larger sample size, to further understanding. Based on these findings and the paired samples *t* test, the null hypothesis is rejected because there was a change in physiological biomarkers for military veterans following an ocean therapy event.

Qualitative Results

Research Question 3 was: To what extent, if any, does the qualitative data help explain any discrepancies in the quantitative data from the first two research questions? In this section, I describe the multicase study designed to understand the impact of ocean surf therapy at Operation Surf's events from May 2021 through May 2022. This section is presented in four parts with the corresponding themes and subthemes that emerged from triangulating data and findings. Triangulation refers to the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena (Patton, 1999). For data triangulation, I implemented different methodologies and different methods, including (a) surveys; (b) field note journals of participant observations, both verbal and nonverbal; (c) interviews; (d) conversations; and (e) GroupMe text message chats to conduct a robust data analysis to help explain any discrepancies in the quantitative data. This method also gave the participants a voice, helping to enrich the data holistically as a narrative of the participants' experiences, and how participants responded to the ocean therapy program. The themes were: (a) Sense of Respite, (b) Evoking Flow State and Joy, (c) Psychological Safety and Immersion, and (d) Ohana (i.e., *family* in the Hawaiian language).

The qualitative approach used in this study helped provide information about human aspects of different phenomena such as opinions, emotions, or relationships (Mack et al., 2005). The qualitative data focused on Research Question 3, helping to explain discrepancy in the quantitative experience while helping to enrich understanding of the experience and impact. Because qualitative research focuses on discovery and description, it is central to interpret the meaning of different experiences (Denzin & Lincoln, 1994; Jiménez-Luque, 2018). Thus, I included a qualitative methodology component in this mixed methods study. Mixed methods research is an approach to inquiry that combines or associates both qualitative and quantitative forms and approaches, involving philosophical assumptions, and the mixing of both approaches in a study, resulting in a study that is more than simply collecting and analyzing both kinds of data; it also involves the use of both approaches in tandem so the overall strength of a study is greater than either qualitative or quantitative research alone (Creswell & Clark, 2007).

Creswell (2014) explained case studies are a strategy of inquiry in which the researcher explores a program, event, activity, process, or individual(s) in depth. Researchers collect detailed information using a variety of data collection procedures over a sustained period of time (Stake, 1995). For this study, I used the May 2021 through May 2022 time period and included all six weeklong Operation Surf ocean surf therapy events. According to Stake (1995), a case study is a design frame where the key is to be eclectic in terms of analysis. The focus of the qualitative data pertained to Research Question 3. In this section, I review and discuss the qualitative findings twofold: in the context of helping to explain any discrepancies in the quantitative data, and how participants responded qualitatively through participation in the Operation Surf ocean surf therapy event. All participants have been provided pseudonyms for confidentiality.

The qualitative component of this research study was a mini ethnographic case study that included participant observations captured in a field notes journal, along with interviews conducted during and around Operation Surf events located on the west coast of the United States. The use of multiple sources of data (i.e., data triangulation) is a way of increasing the internal validity of a study (i.e., the extent to which the method is appropriate to answer the research questions; Stake, 1995). Triangulation means the researcher used data from a variety of sources and applied a variety of methods, which gains knowledge that can be more reliable due to the number of approaches (Bryman & Bell, 2011). Ethnography can help researchers explore the feelings, beliefs, and meanings of relationships between people as they interact in their culture or as they react to others in response to a changing phenomenon (Fields & Kafai, 2009). For this analysis, I also used transcripts from the GroupMe text chat application via cell phone used by Operation Surf specific to each ocean surf therapy event. The GroupMe text chat group was created with Operation Surf for the participants to have an easy to use, convenient way to communicate and connect with the other participants and organization team members while on site during events and remained a central hub of communication among the group following the events.

I conducted this research near the California surfing beaches of Avila Beach, Santa Cruz, Capitola Beach, Morro Bay, and Hollister Ranch where the organization held ocean surf therapy events in different cities at various times during the May 2021 to May 2022 time period. According to Creswell (2014), case studies are a design of inquiry researchers use to analyze a case, event, or process where one or more individuals are involved in depth. In addition, it also describes and analyzes a phenomenon in a specific time or place (Creswell, 2013). The case study approach is particularly useful to employ when there is a need to obtain an in-depth appreciation of an issue, event, or phenomenon of interest in its natural and real-life context (Crowe et al., 2011). Operation Surf's six weeklong events during the May 2021 through May 2022 timeframe provided an event in its natural, real-life context, as a specific time and place, which is what Stake (1995) called a collective case study. A collective case study involves studying multiple cases simultaneously or sequentially in an attempt to generate a still broader appreciation of a particular issue. This option offers the advantage of making comparisons across several cases and for replication (Crowe et al., 2011). Simons (2009) argued a case study is an in-depth exploration that focuses on the different complexities of perspectives held by a specific project, institution, or system.

For the qualitative component of this research study, I used a framework approach due to its practicality. The approach comprised of five stages (i.e., familiarization, identifying a thematic framework, indexing, charting, and mapping and interpretation). The effort of identifying a thematic framework involved identifying key themes, then assigning them a code that best captured the essence of the theme. Based on my rigorous analysis and findings, I suggest participating in ocean therapy had numerous impacts on participants. After winnowing the data, I identified four key themes in which the Operation Surf ocean surf therapy event cultivated, including: facilitating a sense of respite, evoking flow state and fostering joy, encouraging psychological safety and immersion, and curating a sense of ohana. These impacts translate into confidence, self-efficacy (i.e., the belief in someone's own abilities), a reenergized health focus, opening communication channels, and helping to reduce common symptoms of PTSD (e.g., avoidance). This research supports other research discussed in the literature review that ocean therapy has a positive impact on participants and supports the value of exercise as medicine, including blue care and conducting physical activity outdoors, in water, on water, or around water (Nichols, 2014).

After analyzing the data, I compiled information as a mini ethnographic case study, letting the words of the Operation Surf participants speak as often as I could. I wanted to mitigate my personal bias and also to allow their thoughts to stand on their own and describe the impact with their own words. The quotes I chose were directly from events throughout the course of the study and chosen because they depicted themes that emerged from analysis. These quotes are just one person's opinion but are used to illustrate an existing pattern that summarizes the impact and experience of participants.

Respite

Based on the analysis and findings of this research, nature-based activity, specifically ocean surf therapy, seems to facilitate a sense of respite from PTSD. Caddick et al. (2015a) defined *respite* as a fully embodied feeling of release from suffering that can be cultivated through surfing. Respite keeps people in the here and now, which decreases ruminating.

Nicholas, a participant in October 2021, shared, "This is the most I've smiled in a long time. I haven't smiled this much in 15 years, and it feels good. It's been supporting the mission, work, work, work . . . and to get to break that up feels really good." Later, he shared, "I would not rather be anywhere else, really all highs today, thanks for this." Embodying the present moment was important, especially as his self-proclaimed high point pointed to a strong feeling of respite experienced during surfing. Brent, a participant in the July 2021 group, shared:

> I am so grateful for this program. This was the first time since deployment that I have been able to be present; to stop worrying. I haven't felt this way in 6 years. I came here broken. Thank you for being a part of my healing. I love you all and am so grateful.

Participant Christine spoke about "the playing aspect of surfing" over dinner together with the group, and that "feeling of enjoyment" and "being immersed in the moment." She stated it gave her "enough time to calm down and enjoy and watch everyone kick ass and do so great." She concluded by sharing, "The things that bang away in my head all day finally just shut up." Csikszentmihalyi and Bennet (1971) hypothesized "in games, the rules are relatively few and clear; within their boundaries we can abandon ourselves to competition and forget, at least intermittently and for a short spell, the nagging needs of our individual selves" (p. 47). This research seems to be in line with Christine's comments of playing, abandoning the self, and forgetting the needs of life, appearing in a state of respite as a release for the present moment.

Nearly all participants shared stories of difficulty dealing with PTSD symptoms, and some also shared at length about their suffering associated with PTSD. Caddick et al. (2015b) observed the effects of surfing related to subjective well-being, showing surfing as a vehicle for pursuing pleasure rather than for loftier notions of psychological growth and development. Surfing positively influenced subjective well-being in two ways. For one, it helped push PTSD symptoms into the background. Additionally, participants could experience respite through surfing, which protected the veteran's well-being against some of the more serious problems (e.g., suicide) that can be associated with PTSD. This study concurred with Caddick et al.'s findings in which the observed feelings of respite promoted well-being. This study also suggests psychological growth occurs simultaneously because the stories shared all seemed to indicate an improvement or progress of navigating PTSD symptoms, at least in the short term. The veterans' stories showed surfing worked to keep them in the present moment. John, a participant in May 2021—who fortunately lived near Operation Surf's headquarters in Avila Beach, California—came to visit the July 2021 event. He gave me a big hug and shared, "I'm surfing twice a week now, getting in the water has been fantastic. I'm really getting into it, living in the now and loving it. I'm healthier, I've lost weight, and I'm happy!"

Previous literature has highlighted the sense of accomplishment from the act of surfing, in addition to the focus required and social connectedness to fellow surfers, which is transferrable to other activities, can enhance respite (Marshall et al., 2020). John's story seemed very in line with the notion that the act of surfing, social connectedness, and sense of accomplishment enhanced his respite.

Going surfing and experiencing feelings of respite provided the veterans with a positive boost and charge of emotion. The symptoms and difficulties associated with PTSD involve reliving the past. Experiencing respite through surfing appeared to be beneficial for the veterans because it allowed them to engage fully in the present moment, experience mindfulness, and encouraged or facilitated an ability to keep the past in the past, at least temporarily. In the case of John specifically, surfing gave this veteran something to look forward to that helped prevent ruminating over his past trauma. Respite can be a positive feeling of release from struggle associated with PTSD, bringing temporary relief from suffering.

Flow and Joy

During ocean therapy, participants' reports of being present and fully immersed in an activity strongly resembled the explanation of flow state. In positive psychology, a flow state is the mental state in which a person performing some activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity, which can be characterized by the complete absorption in what an individual does, and a resulting transformation in their sense of time (Ellis et al., 1994).

Csikszentmihalyi and Graef (1975) created the concept of flow, which got its name because during initial research interviews, several people described their flow experience using a metaphor of a water current carrying them along. Previous research has suggested flow made lives happier and more successful through positive affect and better performance (Csikszentmihalyi, 1997; Csikszentmihalyi & Csikszentmihalyi, 1990). Csikszentmihalyi outlined a theory of flow where people are at their happiest when they are in a state of flow. Flow research has a striking resemblance to respite because both involve safety in the present moment. During the July event, Charles shared, “Being in gratitude here, truly being here now, I’m feeling the healing. No lows today because I’m in my high right now.” Participant Brian shared, “When you’re in the water, those things just go away. There’s nothing else but the waves. While I was surfing, I was happy, I was smiling.”

In a state of flow, a mind is fully conscious to the present moment, with no mental space devoted to things the individual has to do later or worries about the future. Brandon shared he was able to eliminate outside thought and concern about other things to focus only on the waves. Nakamura and Csikszentmihalyi (2001) identified six components of flow, including (a) intense and focused concentration on the present moment, (b) merging of action and awareness, (c) a loss of reflective self-conscious, (d) a sense of personal control, (e) an altering of an individual’s subjective experience of time, and (f) experience of the activity as intrinsically rewarding. Csikszentmihalyi (1975) shared:

> They concentrate their attention on a limited stimulus field, forget personal problems, lose their sense of time and of themselves, feel competent and in control, and have a sense of harmony and union with their surroundings. They cease to worry about whether the activity will be productive or whether it will be rewarded. . . . They have entered a state of flow. (p. i)

This description strongly resembles Brian’s description of his mental state: focused, conscious, present, and content.

Other participants spoke of the freedom they felt or experienced while surfing: Brian, a participant shared, “Nothing compares what I feel in the ocean or catching a wave and coming out of it. It’s just this special feeling.” Similarly, Brad stated:

> You're doing things you thought you'd never do. Set a goal. Pick a goal that's achievable. Don't pick something that's too much, don't set yourself up for failure. We're all in this shit together. When you get to the beach. It all melts away. You get to just be.

Veterans repeatedly spoke of the intense focus required during surfing, the loss of self, the distortion of time, and how rewarding it was to be surfing. Veterans also described feeling intrinsic motivation, where you are doing the task solely for the enjoyment of the activity, without any other rewards or apparent reason other than being present.

Previous flow state research has been connected to infusions of neurochemicals, which can enhance pleasure, improve physical and mental performance, and sharpen creativity (Csikszentmihalyi & Csikszentmihalyi, 1990). Caddick and Smith (2014) reported surfing generated positive emotions and evoked feelings of pleasure and joy in veterans, as expressed through recordings in fieldnotes he gathered. One of the biggest observations I noticed, concurrent with Caddick and Smith's (2014) findings, across every event, by numerous veterans and with great frequency, was positive emotions (e.g., joy). Exhibited by laughs, smiles, and hugs, a pervasive sense of joy could be felt at every Operation Surf event. When present at the events, I could almost feel energy getting unstuck. Trauma inevitably leaves traces of stress on minds, emotions, and bodies, and the necessity of working past trauma as the body keeps the score (van der Kolk, 2014). Involving a range of therapeutic interventions, including various forms of trauma processing, such as play, activating the brain's natural neuroplasticity, can empower the ability to reclaim ownership of their bodies and lives.

In field notes and journal observations as outputs from the events, I frequently observed and commented on the felt sense of joy, optimism, and a renewed framing of perspective at the event, which constituted a can belief, not the pessimistic cannot. Claro et al. (2016) found a growth mindset (i.e., the belief that intelligence is not fixed and can be developed) is a comparably strong predictor of achievement. The growth mindset intervention communicates a memorable metaphor: that the brain is like a muscle that grows stronger and smarter when it undergoes rigorous learning experiences (Aronson et al., 2002).

Crawford (2016) found ocean surf therapy positively impacted veterans' self-efficacy, based on Bandura's self-efficacy theory, or the belief in oneself. Participant Brent shared openly:

> I haven't been this happy in a long time. I've let myself go, gained weight, and I have no one to blame but myself. The camaraderie here is the stuff I haven't felt in so long; the enthusiasm is contagious. It's called Operation Surf, but it's all about the joy. This is the happiest I've been in years.

Another veteran, Juliet, epitomized positive emotions, expressing joy in the GroupMe text chat to her group after the event. She stated, "The ocean is beyond powerful. It's magical. It has brought peace, joy, friendship, positivity, bravery and harmony to my heart and soul. Thank you for everything this organization has done for me and my fellow brothers and sisters." Another participant, Ben, shared a similar but different version of positive emotions when discussing an experience, he had once back home with his family. He shared:

> So, I just put my son to bed. I turned his noise machine on and changed it from rain to waves. Immediately, my heart rate slowed, and I felt more relaxed. I can't say it enough how much this experience changed me.

During one special event where there were active-duty participants from the Brooks Army Medical Center in Texas, the director of the recreational therapy programs who traveled with her patients for the ocean surf therapy exclaimed, "We don't make therapy fun; we make fun therapeutic." This approach and attitude captured the joy found in the event, the intrinsic motivation of flow state, and doing an activity solely for the sake of doing it where a person is fully immersed in what they are doing; this approach is characterized by a feeling of absorption and fulfillment, during which temporal concerns are typically ignored (Csikszentmihalyi & Csikszentmihalyi, 1990). Additional research is encouraged to understand the extent to which there could be a correlation between intrinsic motivation, flow state, and joy, specifically in conjunction with ocean surf therapy.

Psychological Safety

As discussed in the literature review, many military veterans who return from deployment have a difficult time adjusting to civilian life due to the impact of their experiences in these conflicts, causing functional and social disruption and impacting them through mental health issues such as PTSD (Benninger et al., 2020; Crawford, 2016; Milliken et al., 2007; Oman & Bormann, 2015; Rogers et al., 2014).

Psychological safety has been a focus of much research dating back to the 1960s; it was first explored by pioneering organizational scholars but remains supremely relevant in the 21st century in part because of the enhanced importance of learning and innovation in today's organizations (Edmondson & Lei, 2014). In 1965, Massachusetts Institute of Technology professors, Schein and Bennis, argued psychological safety was essential for making people feel secure and capable of changing their behavior in response to shifting organizational challenges (Edmondson & Lei, 2014). Schein (1993) argued psychological safety helps people overcome the defensiveness or learning anxiety that occurs when they are presented with data that contradict their expectations or hopes. With psychological safety, individuals are free to focus on collective goals and problem prevention rather than on self-protection. From a practical perspective, psychological safety is a timely topic given the growth of knowledge economies and the rise of teamwork in the workplace, combined with research suggesting it enables people to learn and perform (Edmonson & Lei, 2014). During the Operation Surf ocean surf therapy programs, the events appeared to have the ability to help veterans overcome a pervasive sense of social isolation associated with PTSD. My observations suggested that participating in the activities helped induce feelings of social connection and psychological safety. Participants seemed to evoke more confidence, self-efficacy, physical and mental health, a sense of accomplishment, and a return to self, as exemplified in the following story originally shared in the events GroupMe chat. Rita shared:

> I wore a dress last night, but not just any dress. A low cut, backless, high slit dress. A dress 3 months ago I would have laughed at you if you told me to try it on. Three months ago, I would have stayed in my sweatshirt and baggy sweatpants and avoided all social events. Three months ago, I couldn't look in the mirror or stand the feeling of someone's eyes on me without making my skin crawl. This wasn't just any dress, this was my F.U. to the committee. This dress signifies a journey I wouldn't have been able to stay on without y'alls help. You helped get me here and I will forever be grateful for that. Wearing a skintight wetsuit with nothing to hide was the first step, nothing bad happened, and no one noticed! I can't tell you how each and every one brought out my smile again and gave me the strength to come home and say F. U. to the committee. This is me [pictures shared in chat]. Thank you! Just wanted to make y'all proud, facing fears and pushing through the doubt staying true to ourselves, and celebrate the big and small obstacles we face!

A focus on mental health in the 21st century further casts this research into the spotlight. Psychological safety as a term has gained additional notoriety after Google published research that stated psychological safety was a potent factor in high performance. This factor was determined through analysis of interviews of 180 teams as part of the Aristotle Project, an internal company project sought to identify why some teams outperformed others (Nowack & Zak, 2021). Research has shown a psychologically safe environment enables divergent thinking, creativity, and risk taking and motivates engagement in exploratory and exploitative learning, promoting team performance (Edmondson & Lei, 2014).

As social creatures, human beings thrive in groups, with social relationships having a profound effect on emotional and physical well-being (Nowack & Zak, 2021). Social isolation, social threats, and a lack of psychological safety have been shown to significantly elevate cortisol, the stress hormone, with social threats keeping cortisol high 50% longer than physical threats, impairing the ability to effectively execute tasks and occupying neural bandwidth that individuals could otherwise use to contribute to goals (Dewall et al., 2010; Nowack & Zak, 2021).

Operation Surf, and the activity of surfing, seemed to evoke psychological safety, as exemplified in the following comment. Julie stated:

> I haven't felt that way in a minute. I haven't felt comfortable around men for a while. To see Van's [Operation Surf's founder's] love for instruction, for teaching, for surfing. This is exactly what I needed in that moment. So, thank you.

Brad used the Operation Surf ocean surf therapy program as a catalyst to feel confident enough to make big life changes, such as to stop drinking and focus on health. This decision ultimately helped him to procure a new job to help provide for his family and acquired a better diet and exercise regime to lose 40 pounds. During informal interviews at subsequent events, he shared he had become a better football coach and a better father. Operating his life from a place of psychological safety it is suggested allowed him the confidence and neural bandwidth to contribute to goals such as making decisions to improve health.

The veterans also testified to how the activity of surfing evoked in them feelings of confidence, a restored sense of self and purpose in life, and psychological safety, helping them generate a positive outlook on the future. Charles shared, “It was great to get out there. Operation Surf brought back my love for the ocean. I lost it there for a while, but now I’m riding waves with my daughters and having a good time.”

Several participants exhibited confidence and self-efficacy with a basis of psychological safety, freeing up neural bandwidth to frame perspectives and effectively execute tasks and focus on goals, which is reminiscent of Claro et al.’s (2016) research on growth mindset. Christine captured this essence over dinner to the group, saying, “I didn’t think I would surf a wave today . . . but I did. I rode that thing. I wonder what else I can do?” This concept was also discussed in the literature review because this theme was found throughout previous studies, with people exuding reformed confidence and a belief in themselves found through a sense of accomplishment (Bandura, 1994; Marshall et al., 2020). For example, in the longitudinal work by Google’s People Analytics Unit discussed earlier, psychological safety was identified as the number one characteristic of successful high-performing teams (Bergmann & Schaeppi, 2016). Fostering psychological safety is an effective way to improve performance. Additionally, a focus and commitment to psychological safety seems to have a profound impact on mental and physical well-being, instilling in the individual confidence, self-efficacy, a sense of accomplishment, and a return to self.

Schein’s (1993) research suggests learning anxiety, stemming from the reluctance to try something new for fear of failure, is the basis for resistance to change. Survival anxiety is the realization that people must change to survive, with learning occurring only when survival anxiety is greater than learning anxiety. Schein argued leaders should educate about the realities of needed change, provide good training, coaching, group support, feedback, creating a positive environment to decrease learning anxiety, helping to create a psychologically safe environment to learn and create potential for transformational change. PTSD manifests itself through the symptoms of reexperience, avoidance, negativity, and hyperarousal, which can cause sleep disturbance and other issues. PTSD can cause difficulty with interpersonal relationships, diminished psychological resilience and self-efficacy, poorer mental health and physical functioning, and an increased risk of suicide (Crawford, 2016; Jakupcak et al., 2007; Milliken et al., 2007; Oman & Bormann, 2015; Pietrzak et al., 2009; Vasterling et al., 2009). Applying the concept of learning anxiety and survival anxiety, ideas originally founded in organizational learning and behavior, it is suggested through the observations of military veterans participating in Operation Surf's ocean surf therapy program could help participants through the creation of a psychologically safe environment motivating engagement and promoting performance. This environment allows participants to thrive through social relationships improving their emotional and physical well-being. A lack of psychological safety elevates cortisol levels as discussed earlier but it is unknown what impact ocean surf therapy could have on these neurochemical levels, but additional research could further understanding. Using physiological biomarkers in conjunction with neurochemical levels could provide interesting insight to combine with continued qualitative observations to also further understanding and promote growth, improvement, and well-being. Psychological safety appears to be enhanced for veterans participating in ocean surf therapy providing an environment for growth mindset, a freeing up of the mind allowing restored confidence, motivating engagement in exploratory and exploitative learning, encouraging transformational change.

Ohana

With surfing as the catalyst to keep participants in the here and now and focused on the present, it seemed as if participants focused less on past trauma and helped to facilitate a sense of respite, and in doing so, also encouraged bonding with other veterans. Surfing together as a shared experience gave context to relate to each other positively, and promoted an atmosphere of *ohana*, which translates as family from the Hawaiian language (Dictionary.com, 2018). The ohana vibes were a central theme and purposeful curation by Operation Surf, which were discussed openly, early, and often to help comfortability of the participants (Operation Surf, n.d.-c). An example of this purposeful curation of a sense of family was found every event attended on day one, numerous volunteers would walk to the water's edge where the first surf session was being conducted to shout words of encouragement and cheer on the participants. My personal observation in doing so can contribute to the nervousness of the veterans, especially those with zero experience surfing and little time spent in the vast ocean, however, after witnessing a few events where this activity occurred, I am confident the encouragement was genuine and helped veterans overcome the learning anxiety and to feel loved as part of a newfound family, the ohana of Operation Surf. The concept of ohana is borrowed from the Hawaiian culture, which places immense importance on connection and a sense of community through shared camaraderie and fulfillment. The social support and social bonding were evident through the hugs, high fives, and shouts of support from fellow veteran participants I observed, which were almost endless every day during the Operation Surf events. All six events I attended exuded a positive energy throughout the ocean surf therapy program, with nonstop smiles and social support. Cam, a participant in May 2021, shared, “My mother told me she didn’t love me growing up, but being here now, with this group, I feel loved, and it feels good.” Participant Cam further shared, “Many people need one opportunity; today, you let me be who I can be, not who I was.” This story with the word choice of choosing to highlight the group (i.e., “you let me”) suggests a detour from reliving isolated trauma of PTSD, a severe symptom, but experienced living through the familial aspect as part of the ocean surf therapy cohort group, an ohana or family, not just remaining isolated internally by this veteran. One of the participants discussed at length the tangible benefits she felt since completing the Operation Surf ocean surf therapy event. Carrie shared, “This program is saving lives. I’m now a better mother to my children.”

Discussions over dinner repeatedly eschewed shared camaraderie and fulfillment, a sense of connection, and companionship. The events were able to rapidly break down emotional walls and build a shared community, creating a safe communal aspect with strong social bonding and social support, like a family. Participants frequently shared messages of trust, love, and appreciation of friendships in the GroupMe text chains, offering confidence and a safe space to share and ask for help. Many participants even used the term “ohana” when addressing the GroupMe chats, and often abbreviated the term “fam” (short for family) when writing to the group. When reviewing transcripts and field notes, I repeatedly saw exemplifications of an ohana, including offerings of patience and reiterated support, offerings of love, encouragement, sharing reminders to ask for help, and clarifying that it is okay to not be okay. Numerous times in the text transcripts, participants would thank their newfound ohana for the love and support given and show much appreciation for the love. This type of unconditional love and emotional connection demonstrates love and support, as a family would.

Qualitative Conclusions

The Operation Surf events—including not only the surfing and flow state, but also the camaraderie through shared experience, shared meals, yoga and meditation in the morning, and the evenings spent reliving the day—created respite, an ohana offering social connection, trust, psychological safety, and the positive emotion of joy. Csikszentmihalyi and Csikszentmihalyi (2006) often posed a question as output from research: “What constitutes a life worth living?” (p. 3). Much of the previous flow state research considered quality of life; the research I conducted with Operation Surf included a qualitative component to help explain any discrepancies in the quantitative data. As the qualitative component unfolded and data triangulation continued to occur across more cohorts, more field note journals, new GroupMe text chats for additional cohorts, and time to analyze and code the data, quality of life and Csikszentmihalyi’s research around flow state seemed to crystallize the findings observed. Finding flow state, surfing, and aspiring to overcome learning anxiety, fostering a growth mindset, removing barriers to social isolation encouraging psychological safety and social connection, help constitute a life worth living, and improve quality of life. Through participating as a volunteer and researcher ethnographically, in conjunction with the quantitative data captured through this mixed methods study, it is suggested that participating in an ocean surf therapy program can reduce depression, anxiety, and PTSD symptoms, while improving, trust, community, gratitude, accomplishment, perspective, contentment, and flow. The qualitative research corroborates the story that participating in an ocean surf therapy event was congruent with the quantitative findings, demonstrating a reduction in PTSD symptoms, depression, and anxiety. Thus, the qualitative findings support the quantitative data, whereas the themes that emerged through the mini ethnography of respite, flow and joy, psychological safety, and ohana, were congruent with the reductions in depression, anxiety, and PTSD symptoms, while observing HRV changes, REM sleep increases, and deep sleep increases in the quantitative data. The research suggests surf therapy had a positive impact for veteran participants; however, more research in this area is needed.

CHAPTER 5: SUMMARY AND FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Mental health is quickly becoming a major concern globally due to the prevalence and impact it has on community, society, and health in individuals in terms of both reach and severity. For instance, the U.S. Federal Government spent $280 billion on mental health services in 2020 alone, which was a 6% increase from 2019 and a 52% increase from 2009 (The White House, 2022c). Meanwhile, mental health technology startup companies raised over $5.5 billion in funding in 2021, which was an increase from 2020 of 139% (CB Information Services, 2022). These figures only begin to demonstrate the severity of mental health in economic ramifications, whereas there is also significant additional emotional toll.

Although many different populations are impacted by mental health conditions, one specific population that is especially high risk for these issues is the military community because military conflict, deployment stressors, and combat exposure contribute to risk for mental health problems (Reisman, 2016). Further complicating these issues include barriers to accessing care, cost of care, and a stigma with seeking treatment. These findings powerfully illustrate the numerous negative downstream impacts of war for many military veterans and raises critical questions about appropriate treatment options and barriers to care (Reisman, 2016). Rates of posttraumatic stress disorder (PTSD), suicide, and other lingering effects among military veterans are so alarming that the matter was classified as a national health crisis by the U.S. Department of Veterans Affairs (VA) and Centers for Disease Control and Prevention. Given the severe impact of the debilitating condition of PTSD to an increasing number of individuals, the need for objective, comprehensive, well-funded, and rigorous research has never been more important.

Although several pharmacological approaches have been employed to combat the mental health epidemic, their efficacy is mixed at best, which has led to several novel, nonpharmacological approaches. One such approach is Operation Surf, which is a nonprofit organization that provides nature-based programs advocating the restorative power of the ocean and surfing as a form of wellness for injured bodies, minds, and souls (Operation Surf, n.d.-c). Although the limited research on surf therapy has shown a positive impact on veterans' health, these results were based on self-reported survey instruments that suffered from a series of well-known biases. Fortunately, the introduction of wearable technology (e.g., Whoop bands), or *wearables*, allows researchers to unobtrusively gather physiological data such as heart rate variability (HRV), resting heart rate (RHR), rapid eye movement (REM) sleep, and deep sleep, among a myriad of other data points. Wearables offer an opportunity to use new technologies to measure therapy effectiveness while also validating or invalidating traditional survey assessment data and building more research and data around topics such as alternative therapy ocean surf therapy. The aim of ocean therapy is to reduce PTSD symptoms through a supportive group program that primarily uses surfing as the treatment modality and focuses on promulgating camaraderie among other veterans with PTSD (Rogers et al., 2014).

The purpose of this mixed methods study was to collect data for analysis and insight using new technologies to measure therapy effectiveness. Specifically, the goal was to understand how Operation Surf's weeklong ocean surf therapy program impacted psychological, physical, and functional outcomes for veterans seeking mental health treatments for symptoms of PTSD. Building upon previous research (e.g., Crawford, 2016; Rogers et al., 2014), I used survey data in this study to measure depression, anxiety, and PTSD, together with data generated from Whoop bands, to produce a more robust set of programmatic efficacy inferences for six cohorts of military veterans who participated in Operation Surf between 2021 and 2022. Furthermore, I included a qualitative data component for richness, giving the study a full spectrum of data.

Using wearable technologies through a partnership with Whoop bands gave me access to collect new data, gathered outside the laboratory in field settings, while also giving me the ability to validate self-reported assessment data. These data can inform future research designs. Additionally, introducing wearable technology can encourage analytical, data-driven decisions for mental and physical health. These new data could help identify appropriate treatment options and validate more cost-effective solutions, while eliminating some of the existing barriers to care. Leadership requires objective and solid research and findings to make proper decisions. This research could catalyze a strong political strategy to argue for a share of the resources for veterans' mental health treatment. I hoped to encourage future research that builds and iterates upon these data to help leaders enrich public policy care decisions regarding military veterans and health care.

Summary of Findings

With this mixed methods research study, I created a new data set using new technologies to measure therapy effectiveness. The data set produced included survey data, physiological biomarker data, and qualitative data. I used the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders V (DSM-5; i.e., PCL-5) survey to measure PTSD symptoms, the Patient Health Questionnaire Eight (PHQ-8) to measure depression, and the Generalized Anxiety Disorder Scale (GAD-7) to measure anxiety. After paired samples *t*-test analyses, I found participants had a statistically significant reduction in PTSD symptoms, depression, and anxiety immediately after the ocean therapy event. The physiological biomarker data also showed change and improvements in these areas but require further analysis because using wearable technology in the field to gather data is new technology expanding the field of research and will require time and expertise to further understand and validate. However, this study did demonstrate feasibility in generating new data sets by using new technology to measure therapy effectiveness and examining the novel treatment modality of ocean surf therapy, which showed positive results across numerous metrics, including strong support in the qualitative findings.

Previous research conducted with combat veterans has revealed PTSD is associated with diminished well-being, poorer mental and physical health functioning, and increased risk of suicide (Jakupcak et al., 2007; Vasterling et al., 2009). PTSD has been shown to cause depression, anxiety, anger, sadness, and lower levels of self-efficacy (Crawford, 2016). In the next sections, I discuss the data that demonstrate changes in PTSD symptoms, depression, and anxiety, both statistically and clinically, after participating in an ocean surf therapy program. I also share conclusions, make recommendations to harness the momentum from this new data set, address limitations, and discuss the future state of this topic.

PTSD Symptoms

PTSD is a source of dysfunction for veterans, with the rates of treatment for veterans remaining low because dynamics of military culture present several barriers to treatment (e.g., stigmas), which often prevent veterans with PTSD from seeking help from mental health professionals, shown to be associated with an increased risk of suicide ideation and poor adherence to exercise (Hoge et al., 2004; Radomski & Brininger, 2014; Sareen et al., 2007). Even without a physical injury, veterans could develop mild to severe cases of PTSD and PTSD symptoms, which could create daily dysfunction and the need for treatment to improve quality of life and well-being (Radomski & Brininger, 2014).

Using ocean surf therapy as the treatment modality, with the PCL-5 to measure change, military veteran participants in this study exhibited a 38% reduction in PTSD symptoms immediately after the event ($p \leq .01$), with a 35% reduction in PTSD symptoms when scored 30 days following the event ($p \leq .01$). When analyzed by gender, female participants had a 48% reduction in PTSD symptoms immediately following the event ($p \leq .01$). Male participants had a 32% reduction in PTSD symptoms immediately following the event ($p \leq .01$) and a 39% reduction in PTSD symptoms when surveyed 30 days after the event ($p \leq .01$), which seems to suggest the males scores continued to improve following the event, a promising finding which should justify further research. After a review of these findings and the paired samples *t*-test results, there was a statistically significant reduction in PTSD symptoms following participation in the ocean surf therapy events for military veterans.

From a clinical analysis perspective, the PCL-5 survey for all participants had a 28% reduction in PTSD symptoms immediately following the event compared to prior to the event, using the symptom severity measure, and a 20% reduction using the symptom cluster approach. All participants showed a 64% reduction in PTSD symptoms when surveyed 30 days following the event compared to prior to the event, using the symptom cluster approach, and a 48% reduction using the symptom severity approach. On an individual basis, 86% of participants (i.e., 19 out of 22) who completed the survey before and immediately after the event saw a reduction in severity score, and 77% of participants (i.e., 17 out of 22) scored a 10–20-point clinically meaningful reduction in total score and severity. Of the participants who completed the survey before the event and 30 days after ($n = 21$), 90% of them (19/21) showed a reduction in severity score, of which 71% of them (15/21) showed a clinically meaningful 10–20-point reduction in total score and severity. These values and changes demonstrated PTSD symptoms improved immediately after the therapy program and 30 days after the program.

Rogers et al. (2014) found PTSD symptoms improved in a small group of veterans using ocean therapy but suggested using a larger sample size and better program evaluation in future studies. Crawford (2016) used the PCL-5 to measure if there was a decrease in PTSD symptoms at similar time points to this research study. Crawford found a reduction in PTSD symptoms; however, the reduction in PTSD symptoms was significantly less 30 days after the therapy than the reduction experienced immediately after therapy. In this current study, I observed reductions in PTSD symptoms immediately after the event and 30 days after the event. This research did not observe the significantly less reduction 30 days after the event that Crawford observed. This researcher also added layers of analysis segmented by gender, recording a bigger reduction for female participants than male participants, but both reductions were found to be significant.

Depression

Previous literature examining military veterans found guilt, depression, substance abuse, and suicidal ideation remained high, resulting in significant costs of treatment and justifying a need to conduct more research to identify a low cost and scalable treatment modality while eliminating stigmas and barriers to care and informing public policy care decisions (Adler et al., 2011; Elbogen et al., 2010; Iverson et al., 2013; Killgore et al., 2008; Owens et al., 2014). Using the survey scores from the PHQ-8 to determine levels of depression, military veteran participants in this study saw a 44% reduction in depression immediately following the event ($p \leq .01$), with a 30% reduction 30 days following the event ($p \leq .01$). In particular, male participants demonstrated a 42% reduction in depression immediately following the event ($p \leq .01$) with a 29% reduction 30 days following the event ($p \leq .05$). Female participants showed a 50%

reduction in depression immediately following the event ($p \leq .01$) with a 32% reduction in depression 30 days following the event ($p \leq .05$).

Using the PHQ-8 survey's clinical analysis scoring guidelines, there was a 1% reduction in severe depression (i.e., the highest classification) immediately following the event, followed by a 2% reduction in severe depression 30 days following the event. For the second highest classification (i.e., moderately severe), results showed a 44% reduction in moderately severe depression immediately following the event, followed by 36% reduction 30 days after the event. Prior to the event, 9% of participants had no depression, with an additional 32% of participants classifying as no depression immediately after the event, for a total of 41% reporting no depression following the ocean surf therapy event. When comparing scores prior to the event to 30 days following the event, the 9% who reported no depression prior increased to 31% at 30 days following the event, which was an increase of 22% of participants reporting no depression. The paired samples *t* tests showed there was a significant effect of the time point when PHQ-8 was taken, with a greater reduction in score showing immediately after the event than compared to 30 days following the event, though both time points showed significant improvement in reducing depression compared to prior to the ocean surf therapy event.

Anxiety

As previously discussed in the literature review, anxiety can cause significant problems for military veterans. Even secondary trauma can have an impact on veterans, and research has suggested veterans' children are more likely to have behavioral problems such as increased anxiety and aggression (Dekel & Monson, 2010). Researchers examining surfing have found experienced surfers are less prone to anxiety and depression, and surfing may result in elevated mood (Levin & Taylor, 2011; Pittsinger & Liu, 2010). Surfing requires mental focus and physical strength, which can reduce stress, reduce anxiety, and improve sleep (Guszkowska, 2004; Sharma et al., 2006).

Part of this research study focused on understanding to what extent, if any, there was a change in anxiety and other mental health measures as measured by the GAD-7 immediately after the event and 30 days following an ocean surf therapy event. Building upon the aforementioned research, the data collected from this study suggested a positive impact and a reduction in anxiety for the military veteran participants. For all participants from May 2021 through May 2022, there was a 59% reduction in anxiety immediately following the event ($p \leq .01$) and a 30% reduction in anxiety when surveyed 30 days after the event at Time Point 3 ($p \leq .05$). When segmenting the survey scores by gender for anxiety, female participants displayed a 54% reduction in anxiety immediately after the event ($p \leq .05$) and male participants had a 61% reduction in anxiety immediately after the event ($p \leq .01$).

Using the clinical analysis scoring for the GAD-7 survey for all participants, participants with the highest classification of severe anxiety saw a 30% reduction immediately following the event, and a 26% reduction in severe anxiety 30 days following the event. Participants with the next highest classification (i.e., moderate anxiety) had a 16% reduction in anxiety immediately following the event and 11% reduction 30 days after the event when compared to prior to the event. Similar to PTSD and depression results, the reduction in anxiety was greater immediately after the event, though both time points still recorded significant reductions in anxiety following participating in the ocean surf therapy event.

Physiological Biomarkers

Paired samples *t*-test analyses of the quantitative physiological biomarker data determined there was some statistically significant change, though additional research is needed to further understand these changes. For instance, HRV decreased 12% during the event ($p \leq .05$), while increasing 7% after participating in the event; however, this change was not statistically significant ($p < .11$) when using a paired samples *t* test to compare means to analyze for the entire group ($n = 33$). The group HRV minimum, maximum, mean, and median were all higher 30 days following the event. At an individual level, 82% of participants saw an increase in their HRV mean score 30 days after the event compared to during the event, and 65% of participants saw their HRV mean score increase 30 days after the event compared to before the event. Additionally, 78% of male participants had higher HRV 30 days after the event compared to during the event, while 70% of all participants had higher HRV 30 days after the event compared to during the event. RHR increased 4% during the event for all participants ($p \leq .01$). When analyzed by gender, female participant mean RHR scores increased 6% ($p \leq .01$) and male participant scores increased 3% ($p \leq .05$).

When using paired sample *t*-test analysis, deep sleep increased 7% for all participants during the event compared to before the event ($p \leq .05$). Female participants had deep sleep increases of 27% during the event compared to before the event ($p \leq .05$). REM sleep for female participants was found to be 18% during the event when compared to 30 days after the event ($p \leq .05$).

Conclusions

The results of this study demonstrated support for ocean therapy as beneficial for veterans with PTSD and suggests a new treatment modality that could increase the quality of life for PTSD afflicted veterans, their families, and their friends and peers; however, more research is necessary to further understand this phenomenon. After conducting paired samples *t*-test statistical analyses and using respective clinical scoring guidelines with surveys and physiological biomarkers data, I determined there was a statistically and clinically significant effect on PTSD symptoms, depression, anxiety, and physiological markers for military veterans immediately following the event and 30 days after participating in the Operation Surf ocean surf therapy program. The results showed a decrease in PTSD symptoms, depression, and anxiety.

The physiological biomarker data showed various improvements across the data set, including increased deep sleep, increased REM sleep for female participants, and HRV decreases during the event while increasing in the 30 days following the event. Individually, HRV increased following the event for a large majority of all participants. Furthermore, the qualitative research captured through the mini ethnographic components of participating in the ocean surf therapy programs from May 2021 through May 2022 supported the quantitative findings, demonstrating respite, flow and joy, psychological safety and immersion, and ohana, which support a notion of improved psychological, physical, and psychosocial outcomes for military veterans. This research supports other research discussed previously in the literature review that ocean therapy has a positive impact on participants and supports the value of exercise as medicine; specifically, blue care (i.e., conducting physical activity outdoors, in the water, on the water, or around water) has a positive impact on participants (Britton et al., 2020; Crawford, 2016; Nichols, 2014; Rogers et al., 2014).

The purpose of this mixed methods study was to collect data for analysis and insight using new technologies to measure therapy effectiveness. Specifically, the purpose of this study was to understand how Operation Surf’s weeklong ocean surf therapy program impacted psychological, physical, and functional outcomes for veterans seeking mental health treatments for symptoms of PTSD. New technologies can be introduced to help measure therapy effectiveness, and wearable technology could be useful for encouraging mental and physical health in military veterans with PTSD. These early results justify further examination, while additional research is necessary to further understanding.

These initial positive results—in conjunction with the innovation in technology through rapid advancements in hardware, software, and the ubiquity of mobile devices—could yield incredible insight in extending research capabilities, fostering entirely new frontiers in data and healthcare, furthering understanding, advancing diagnostic and therapeutic capabilities, delivering more effective and efficient health care services, and ushering in salubrious effects. This research produced a more robust set of programmatic efficacy inferences to further understand the impact of ocean surf therapy on military veterans. Data from this study supported ocean surf therapy as a viable, complementary, alternative treatment modality supporting military veterans, though more research is necessary to further understand this phenomenon.

Limitations

Wearable technology that gathers physiological data is a new field with little rigorous existing research, and studies using wearables to measure therapy effectiveness are even scarcer. Having a limited field of previous research will require additional studies and data sets to begin to understand the true physiological impact. Technology is improving, and data captured via these wearable devices are rapidly expanding, but it will take time to conduct and analyze further studies, especially to begin suggesting impact and outcomes solely based on physiological data alone. Whoop currently supports a low degree of bias and low precision errors compared to the industry gold standard polysomnography (Berryhill et al., 2020). One study participant who already suffered from poor sleep shared the small green light located on the underside of the Whoop when worn on the wrist was keeping her up at night. During the time of this research study, Whoop launched a new version of their hardware (i.e., 4.0), which added the ability to wear the device in various articles of clothing, such as boxers and compression pants. This change is just one small example of how slight iterations in the technology could continue to improve, helping to gather more data and unlock additional insight. Given the massive amount of investment in this technology, hardware and software will continue to improve, also allowing time for additional research to be conducted and analyzed.

As discussed in the literature review, there is a growing body of research on ocean surf therapy; however, existing research remains limited. Early results indicate positive benefits for a handful of participants but varying methods and populations to date have kept generalizability low (Crawford, 2016; Hignett et al., 2018; Marshall et al., 2019; Rogers et al., 2014). Durations, participant activities and involvement, and even weather conditions and equipment vary widely, which could affect program outcomes, and make attempts to find proper dosage for a medicalized approach for this treatment modality difficult. I used a nonprobability sampling strategy because the study was limited to military veterans who enrolled in the ocean therapy program with Operation Surf from May 2021 to May 2022. As a result, selection effects may have occurred because veterans who enroll in alternative therapy such as an Operation Surf event might be veterans who are actively trying to assimilate into civilian life, and/or veterans who are more open and receptive to treatments for PTSD. These veterans may embody a more positive attitude and hope toward recovery, which could affect their PTSD symptoms, depression, and anxiety. As such, the findings of this study may not necessarily be generalizable to all veterans.

Because I served as a volunteer/shuttle driver/water safety person for participants during the event, it is unclear to what extent social desirability on the part of participants may have influenced their responses to several of the outcome measures, specifically the self-report survey assessments and qualitative components. Additionally, the ongoing COVID-19 global pandemic and the concomitant cancellation and scaling back of many of the key activities of Operation Surf's camp, including the number of participants reduced as mandated by the state of California, may have reduced the power of the intervention. Surf instructor preparation and methodology of instruction varied across different programs, which further complicated understanding results and attributing causal inference (Marshall et al., 2019).

Although there are many psychological benefits demonstrated through the research on surf therapy, more research is needed to understand and design programs for optimal efficiency, cost, and scale. A limitation existed in this current study around privacy and healthcare data due to the Health Insurance Portability and Accountability Act of 1996 because many participants were concurrently taking medication or involved in other forms of therapy at the time of intervention (Walter et al., 2020). This limitation further makes the impact of surf therapy difficult to isolate and quantify. The mixed methods approach used with qualitative analysis, in conjunction with additional quantitative data using common metrics and assessments, produced a more robust analysis, adding new physiological data to further understanding. However, the impact of ocean surf therapy programs remains difficult to assess, even when adding standardization and scientific analysis. These limitations guided the recommendations and future research sections.

Implications for Policy and Practice

Although using new technology to measure therapy effectiveness is in its infancy, there is much promise and excitement at the possibilities of generating new data for analysis to further understanding and increase impact. Ocean surf therapy programs come with a myriad of limitations as previously discussed, but the results and future are promising. In this section, I identify recommendations to combat these limitations and ideas to continue fostering innovation, using new technologies and novel techniques to harness momentum.

A larger sample size is a high priority next step to further understanding of this phenomenon. I used several methodologies and methods in this mixed methods study, including quantitative survey measures, quantitative physiological biomarkers, and numerous qualitative data techniques in attempt to further understanding. This study built a foundation to conduct future studies with a larger sample size generating more data, which would continue to build the data repository for analysis to further understanding.

Previous researchers recommended longitudinal study designs (Walter, Otis, Glassman, et al., 2019), which I conducted in this study, but even longer longitudinal analysis could be accomplished using Whoop's ability to unobtrusively gather data combined with its low cost, producing a scalable model of data collection and allowing for longer study durations with relatively no additional cost because the infrastructure for collecting and analyzing data is already in place.

There has also been growing interest and increasing research in the potential use of outdoor water environments, also called blue care or blue space, in the promotion of human health and well-being (Britton et al., 2020). Using wearable technology could be a way to grow research considerably, with new data collected providing valuable feedback and previously unobtainable metrics to further the field of study. Globally, there is growing interest in the therapeutic potential of nature-based interventions at a policy level (Bragg & Atkins, 2016). Technology will continue to advance, improving reliability and accuracy, though initial research has suggested the data to be viable. Iterations of the technology, combined with considerably more research, could unlock new troves of data, yielding an entirely new field of healthcare.

This study used Time Point 1 (i.e., before the event) to serve as the control. Adding control groups and comparison groups, such as Walter, Otis, Glassman, et al.'s (2019) randomized controlled trial studying surf therapy and hike therapy, could help to understand their respective impacts, and further enhance understanding of this topic. Self-report surveys will most likely remain the gold standard in the short term due to their ease of distribution and low cost, along with documented, proven reliability across numerous studies. Conducting larger studies using the same three surveys as this research study could help to standardize metrics. Further, a focus on newer metrics such as physiological biomarkers could help the therapy ascertain a solid foundation to encourage additional research, both at a policy level and to attract rigorous and well-funded research. Using technology to measure therapy effectiveness positions itself for exponential growth as an industry, enabling healthcare and public policy to unobtrusively gather data while simultaneously encouraging analytical data driven decisions for mental and physical health.

Implications for Future Research

Building on the foundational, novel research conducted in this research study, conducting studies with longer durations and larger sample sizes will greatly enhance the field. Using wearable technology to collect ongoing data can greatly expand on these results. Operation Surf conducts a separate ocean surf therapy program called OS3, a 3-month-long program, where local military veterans in the San Luis Obispo area meet and surf multiple times per week. Conducting similar research using the foundation of this research study, including wearable technology, would be a great next step to further understanding and growing the data set, addressing some limitations such as duration and dosage for optimal benefits, while expanding reach, awareness, and impact.

Using new technology to measure additional markers for therapy effectiveness could be expanded to other physiological biomarkers and treatment modalities. Whoop bands monitor additional variables, even recording physical activity events such as hiking, bicycling, and yoga (Whoop, n.d.). Adding or collecting and analyzing additional biomarkers could not only monitor ocean surf therapy, but—combined with other activities, such as yoga, walking, and hiking—could also yield increased benefits. Lakkireddy et al. (2013) found yoga reduced atrial fibrillation episodes, depression, and anxiety ($p < 0.001$), and improved the quality of life parameters of physical functioning, general health, vitality, social functioning, and mental health domains, finding significant decreases in heart rate, and systolic and diastolic blood pressure before and after yoga ($p < 0.001$). Including wearables in a study such as Lakkireddy et al.'s could usher in strong support for the alternative therapy industry, encouraging strong political support to conduct more research, and building a case to use cost savings from patients who must use healthcare resources more frequently. Using new technologies to measure additional treatment modalities, such as snowboarding, wake surfing, and wake boarding, in addition to ocean surf therapy, could extend the pool of participants wishing to participate and experiment with various new treatment modalities. Even slower physical activities such as fly fishing, sailing, or simpler activities such as star gazing, equine therapy, garden therapy, art therapy, or crocheting would benefit from understanding physiological biomarker responses to participating in these programs. Research on blue space interventions, the use of outdoor water environments in the promotion of human health and well-being, and nature-based solutions have included studies that use modalities such as surfing, river running, kayaking, scuba diving, sail training, fly fishing, and dragon boat racing (Armitano et al., 2015; Britton et al., 2020; Caddick & Smith, 2014; Caddick et al., 2015a, 2015b; Capurso & Borsci, 2013; Carin-Levy & Jones, 2007;

Cavanaugh & Rademacher, 2014; Clapham et al., 2014; Colpus & Taylor, 2014; de Matos et al., 2017; Dustin et al., 2011; Fleischmann et al., 2011; Godfrey et al., 2015; Hignett et al., 2018; Lopes, 2015; McCulloch et al., 2010; McDonough et al., 2008; Mitchell & Nielsen, 2002; Mowatt & Bennett, 2011; Parry, 2008; Rogers et al., 2014; Tardona, 2011; Vella et al., 2013; M. P. White et al., 2016). Many of these nature-based solutions would be ideal candidates for wearables to measure therapy effectiveness.

Flow state is a state characterized by deep enjoyment and total immersion where a person may not notice the passing of time, not think about the task they are doing, or judge their efforts, while remaining completely focused; flow state has been predicted to lead to positive effects and better performance (Csikszentmihalyi & Csikszentmihalyi, 1990). Rock climbers, surgeons, and others who routinely find deep enjoyment in an activity illustrate how an organized set of challenges and a corresponding set of skills result in an optimal experience (Nakamura & Csikszentmihalyi, 2001). Csikszentmihalyi and Csikszentmihalyi (1990) suggested enhancing the time spent in flow state makes people's lives happier and more successful. Initially, researchers supporting these ideas used the experience sampling method, a research procedure for studying what people do, feel, and think during their daily lives, and systematically self-reported to create an archival file (Larson & Csikszentmihalyi, 2014). The experience sampling method has a limitation in that interrupting deep flow destroys the phenomenon. Many aspects of flow remain relatively unexplored, and their investigation might contribute to further development of the flow model (Nakamura & Csikszentmihalyi, 2001). Using new technologies could greatly expand the field of knowledge, ushering in an entirely new field of treatment modalities, with a focus on flow. Caddick et al. (2015b) defined respite as a fully embodied feeling of release from suffering that was cultivated through surfing, providing momentarily relief, and allowing the participant to just be. Embodying the present moment, a sense of respite, and flow state, as described by numerous participants, could be a focus for additional research studies, specifically flow state, to unlock new understanding because prior research has suggested an improvement in quality of life, which this research supports. Previous flow state research has been connected to infusions of neurochemicals, which can enhance pleasure, improve physical and mental performance, and sharpen creativity (Csikszentmihalyi & Csikszentmihalyi, 1990). Further research including wearable technology could generate new data for analysis, while continuing to suggest positive benefits of the experience for participants.

The research findings of this current study could benefit veterans, their families, and the community through their impact, exhibited at the community level through policy changes, causing a shift in financial resources. At the community level, surf programs could increase productivity, improve economics, and reduce healthcare costs. At the personal level, they could reduce PTSD symptoms, depression, anxiety, risk-taking behaviors, thrill seeking, opioid use, and suicide, all in a potentially highly scalable format. This research lies at a valuable intersection of creative delivery format with elements that have been hypothesized to have health benefits for generations; however, until recently, researchers may have never had the tools to harvest the necessary data. The advancement of technology, such as Whoop bands, may provide the ability to uncover the importance of this work and help implement meaningful change and impact at all levels of society.

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APPENDIX: COPY OF INSTRUMENTS

Generalized Anxiety Disorder Scale (GAD-7)

Over the last two weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid, as if something awful might happen	0	1	2	3

Column totals _____ + _____ + _____ + _____ =

Total score _______

Patient Health Questionnaire (PHQ-8)

Name:________________________________

Date of Birth: ______________ Today's Date:______________

Over the last 2 weeks, how often have you been bothered by any of the following problems?	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	☐	☐	☐	☐
2. Feeling down, depressed, irritable or hopeless	☐	☐	☐	☐
3. Trouble falling or staying asleep, or sleeping too much	☐	☐	☐	☐
4. Feeling tired or having little energy	☐	☐	☐	☐
5. Poor appetite or overeating	☐	☐	☐	☐
6. Feeling bad about yourself – or that you are a failure or have let yourself or your family down	☐	☐	☐	☐
7. Trouble concentrating on things, such as school work, reading or watching television	☐	☐	☐	☐
8. Moving or speaking so slowly that other people could have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual	☐	☐	☐	☐

PTSD Checklist for DSM-5 (PCL-5)

PTSD Checklist (PCL) - 5

Name:____ Date:____________________

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to the right to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:	Not at all	A little bit	Moderately	Quite a bit	Extremely
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4. Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?	0	1	2	3	4
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being "superalert" or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

Total _______

IRB Clearance Page