Coping with Posttraumatic Stress Disorder in Returning Troops
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Cybertherapy for Combat Related Posttraumatic Stress Disorder, Pain Management and Physical Rehabilitation Following Stroke

Dennis Patrick Wood, Ph.D., ABPP[a, 1], Mark D. Wiederhold, M.D., Ph.D., FACP[a], James Spira, Ph.D., M.P.H., ABPP[a], Dennis Scholl, Ph.D. [b], Jeff Pyne, M.D.[c] and Brenda K. Wiederhold, Ph.D., MBA, BCIA[a]

[a] *Virtual Reality Medical Center, 6155 Cornerstone Court East, #210, San Diego, CA 92121 (www.vrphobia.com), dpwcapt@aol.com*

[b] *8070 W. Dixon Road, Sumerset, TX 78069*

[c] *Center for Mental Healthcare Outcomes Research, Central Arkansas Veterans Healthcare System, North Little Rock, AR 72114.*

Abstract. The U.S. Department of Veterans Affairs (VA) has not only been at the leading edge in the study of the effects of war on warriors deployed to combat, but it has also been recognized as the leader for treatments in Posttraumatic Stress Disorder, Chronic Pain and Stroke. Virtual Reality Therapy (VR) is a new and growing technology that utilizes computers to create computer-generated virtual, three-dimensional worlds that then can be utilized by patients to successfully treat Posttraumatic Stress Disorder and chronic pain. VR Therapy has also been successfully utilized to assist with stroke rehabilitation. VR Therapy can assist VA with meeting the U.S. Government's mandate to increase the quality of care to a growing number of combat OIF/OEF veterans diagnosed with PTSD, chronic pain and/or stroke.

Keywords. Virtual Reality (VR) Therapy, Virtual Reality Exposure With Arousal Control (VRE-AC), Anxiety Disorders, Posttraumatic Stress Disorder (PTSD), Pain, Physical Rehabilitation, Stroke, physiological monitoring, biofeedback, meditation, Department of Veterans Affairs (VA), Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF)

Introduction

The U.S. Department of Veterans Affairs (VA) has been identified as the world's largest provider of Posttraumatic Stress Disorder (PTSD) treatment, operating 150 specialized PTSD programs nationwide and providing outpatient PTSD treatment to more than 600,000 veterans annually [1]. Managing the pain experienced by Veterans, particularly those 1.5 million Veterans who have served in Iraq and Afghanistan, is "a

[1] Corresponding Author. Virtual Reality Medical Center, 6155 Cornerstone Court East, #210, San Diego, CA 92121, Email: dpwcapt@aol.com

great concern and responsibility for Department of Veterans Affairs (VA)" [2]. Additionally, the relationship of PTSD and co-morbid chronic pain has also been documented, as having treatment strategies being utilized in VA Pain Clinics [3, 4]. The VA also has approximately 80,000 patients who are stroke survivors, with about 15,000 veterans being hospitalized for stroke each year and 2,500 of these stroke patients receiving acute and post-acute rehabilitation services from the VA [5, 6].

1. Department of Veterans Affairs and Treatment for Posttraumatic Stress Disorder, Chronic Pain and Cerebral Vascular Accident

Veterans, diagnosed with combat-related PTSD, have had access to treatment in Veteran Hospitals and Clinics [1, 7-11]. Monson et al [1, 7] described the utilization of Cognitive Processing Therapy (CPT), an exposure therapy, to successfully treat combat-related PTSD. CPT encourages the patient to access memories of a traumatic event (i.e., fire-fight, exploding IED, death of a fellow "combat-buddy", sleepless nights, etc.) and to recognize and feel the associated emotions so that they eventually dissipate; to facilitate emotional processing, CPT targets dysfunctional beliefs about the event(s), the patient's own self, others and the world [1]. Schnurr et al [9] investigated the effectiveness of prolonged exposure versus present-centered therapy for women diagnosed with PTSD. The therapy was provided to patients in 10 weekly 90-minute sessions. Patients were treated in 9 VA medical centers, 2 VA readjustment-counseling centers and 1 military hospital. Women who received prolonged exposure experienced a greater reduction of PTSD symptoms relative to the women who received present-centered therapy [9]. Hamner et al [11] has concluded that "although Cognitive-Behavioral Therapy (CBT), as an exposure therapy, and antidepressants (mainly Serotonin Selective Reuptake Inhibitors) are considered state of the art treatments for PTSD, many patients still have significant symptoms at the conclusion of adequate treatment trials with these approaches".

Of note, the Institute of Medicine concluded that only exposure-based therapies, such as CPT, were recommended as a treatment for PTSD [12]. The Department of Veterans Affairs has agreed with the Institute of Medicine endorsement of exposure-based therapies [13]. Yet, 72% of VHA psychologists "were not at all comfortable" with employing imaginal exposure techniques for PTSD treatment due to a number of reasons including a belief that exposure treatments may increase patients' fear and anxiety to dangerous levels, ultimately worsening symptoms, according to a Rand Study [14]. Further, the Rand Study suggested that the VA needed to develop the appropriate clinical and training strategies that would "increase and improve the capacity of the mental health care system to deliver evidence-based care" [14]. Both the Report of the President's Commission on Care for America's Returning Wounded Warriors and the June 2007 Report of the Department of Defense Task force on Mental Health also have recommended that the VA and DOD should aggressively prevent, develop early intervention strategies for and treat PTSD [15, 16].

2. Department of Veterans Affairs and Treatment for Chronic Pain

Chronic pain has been documented as one of the most frequently co-occurring physical problems for patients both with and without PTSD [2, 3]. To assist with the complex treatment of veterans diagnosed with chronic pain, whether or not they have also been diagnosed with PTSD, various VHA Medical Centers have developed specialized pain management clinics and intensive and interdisciplinary Polytrauma care centers designated Polytrauma Rehabilitation Centers or PRCs [2–4, 17, 18].

Kalra et al [2] surveyed 99 OEF and OIF veterans, and found that 80% of these veterans reported "clinically significant pain". Additionally, more than 80 to 96% of all patients admitted to PRCs had been experiencing pain problems. [2]. In order to achieve the "overall goal of managing polytrauma pain, [which] is to achieve an acceptable balance between pain control and the patient's functional level, a coordinated effort by all interdisciplinary team members is required" [2]. Shipherd et al [3] identified that 66% of patients diagnosed with PTSD, also possessed chronic pain diagnoses including chronic low back pain, general chronic pain, osteoarthritis, persistent headache/migraines and joint pain. Following the completing of a 16-week PTSD treatment program, Shipherd et al [3] reported that the patient's pain rating scores decreased significantly. The documented interaction between psychological disorders and chronic pain has also been noted by Drake et al. [4] who found that 54% of patients in a VA Pain Clinic has also been diagnosed with a psychiatric diagnosis and 73.6% reported prior treatment with an opioid. Given the characteristics of patients enrolled in a VA pain clinic, Drake et al [4] recommended that these patients should be assessed and managed differently than patients in the general veteran VA outpatient clinics. In order to facilitate functional recovery of older adults reporting postoperative pain following orthopedic surgery, Morrison et. al [18] developed a standardized pain management protocol that included daily pain assessments by nursing and physical therapy staff, daily feedback of pain scores to all clinical staff and a standardized pain management protocol. This pain management protocol determined that pain medication was to be administered based on patients' reports of pain on standing and, preemptively, one hour prior to each in-hospital rehabilitation session. Pain medication was adjusted for breakthrough pain. Control patients received "usual care". Morrison et al [18] reported that patients in the intervention group reported significantly less pain at rest and with physical therapy than did the control patients. At six month post-discharge, intervention patients were significantly less likely than controls to report severe pain with walking and were significantly less likely to be taking pain medication.

With the co-morbidity of pain associated with the diagnoses of PTSD and/or TBI, and with the literature that has substantiated increased physical disability and emotional distress secondary to the presence of untreated or undertreated PTSD and/or pain, several VHA clinicians have recommended that early detection efforts and more effective pain treatments need to be developed to prevent or minimize the progressive pathology of pain, PTSD and/or TBI [2 – 4, 17, 18].

3. Department of Veterans Affairs and Treatment for Cerebral Vascular Accident

Stroke-related disease costs the VA more than $1 billion annually [5]. Additionally, the Centers for Disease Control has identified that 1.3 per 1,000 men and 1.5 per 1000 women, under the age of 45 years, experience stroke [19]. Of note, one in 16 deaths are secondary to stroke annually and in veterans with low incomes, the risk of death from stroke is slightly higher [6]. More than one-third of all strokes are recurrent attacks [6].

In order to maximize recovery from stroke, specialized stroke rehabilitation is recommended not only for older patients but also young adults [6, 19, 20].

Jia et al [5] identified 1,953 VA patients who were diagnosed with stroke between 2000 and 2001. Thirty percent of these patients utilized VA care only during their 12-month post stroke period and 70% relied on other healthcare programs. At 12 months post-stroke, about 80% of the study patients had received rehabilitation care. Choi et al [19] have recommended that following acute stroke management and secondary prevention, stroke rehabilitation should be focused on relationship, social, psychological, sexual, quality of life and employment issues. Choi et al [19] mentioned that only about one third of young adults who have a stroke return to gainful employment.

Duncan et al [120] has recommended not only that stroke rehabilitation should be started early, but also that candidates for rehabilitation should receive coordinated, multidisciplinary evaluation and intervention in order to optimize stroke rehabilitation. Further, with muscle weakness and impairments in cognitive functioning being common impairments following stroke, it has been recommended that strengthening and cognitive re-training be included in the acute rehabilitation of patients with muscle weakness following stroke [20]. In evaluating research that investigated the rehabilitation strategies to improve the executive functioning in stroke and TBI patients, Duncan et al. [20] concluded that there is a "benefit from formal problem-solving strategies and the ability to apply these strategies to everyday situations and functional activities was found for patients with executive function and problem solving dysfunction. There is some evidence that the promotion of awareness and self-regulation through verbal instruction, questioning and monitoring can improve problem-solving skills". However, a continued concern for adult stroke rehabilitation is that the equipment for home health rehabilitation is limited [20].

4. Cybertherapy for PTSD, Pain and Stroke

To assist clinicians and researchers to become more aware of the growing body of literature describing the range, availability, and therapeutic effectiveness of Cybertherapy, we describe the role of Cybertherapy in treating three groups of patients commonly receiving clinical services in VHA hospitals and clinics. These three groups of patients include those diagnosed with PTSD, chronic pain and those receiving rehabilitation services following a stroke.

Cybertherapy relies on the utilization of advanced technologies, including virtual reality computer simulations, computer gaming, cell phones, smart phones, PDAs and the internet to provide various healthcare services to patients [21 – 35]. Cybertherapy can augment the effectiveness of current or usual treatments, as well as providing evidenced-based therapies to patients who are currently underserved [22].

The Cybertherapy system relies on visual and auditory representations and a typical setup may run on three computers [21 - 29]. One computer displays the visual and auditory stimuli on a standard computer screen, as well as to the patient through a head-mounted display (HMD) with built-in headphones. The second computer displays the control panel and menu, and this information is used by the clinician to add arousal or "challenge" or other stimulus elements into the virtual environment with single button clicks without disturbing the patient's exploration, viewing or participation in the virtual world. A third computer runs the physiological monitoring (skin conductance, peripheral skin temperature, respiration rate, heart rate, and heart rate variability) and feedback system (J & J Engineering, Inc., Poulsbo, WA), which is utilized to facilitate the patient's learning of arousal control. Training in arousal control, through the use of meditation, paced abdominal breathing and biofeedback, provides the patient with an increased opportunity to gain control over arousal, and in addition allows the therapist to monitor the patient's level of arousal and to adjust or grade the intensity of the exposure in order to optimize treatment outcome [24, 26, 27]. Combining physiological arousal control with psychological VR facilitated exposure therapy has resulted in 66 to 90% treatment effectiveness for anxiety disorders including specific phobias and PTSD [19, 21, 24, 25, 27].

Importantly, computer graphic images and spatial audio, consistent with the orientation and position of the patient's head and/or other parts of their body, are computed in real time as the patient experiences and explores the virtual environment. Virtual environments used for PTSD are immersive (i.e., the patient is experiencing only the computer-generated audio and visual stimuli while "real-world" stimuli are shut out). The clinician communicates with the patient via a microphone linked to headphones.

While immersed in a virtual environment, the patient can sit on a chair that rotates 360 degrees, or they can stand, or they can be laying in a bed or on a rehabilitation table and by using a handheld joystick, the patient can "walk", "run", "drive" or otherwise move through and/or interact with the virtual environment by pushing a button on the handheld joystick. The various virtual environments utilized to facilitate treatment for combat-related PTSD (i.e., Virtual Baghdad, PTSD Convoy, PTSD Village), pain management (i.e., Icy Cool World, Shell Beach, Enchanted Forest, Dream Castle and Vista View) and rehabilitation (i.e., MRRS Warehouse) software and environment models were custom-built by the Virtual Reality Medical Center (San Diego, CA) using 3-D game technology [21–29].

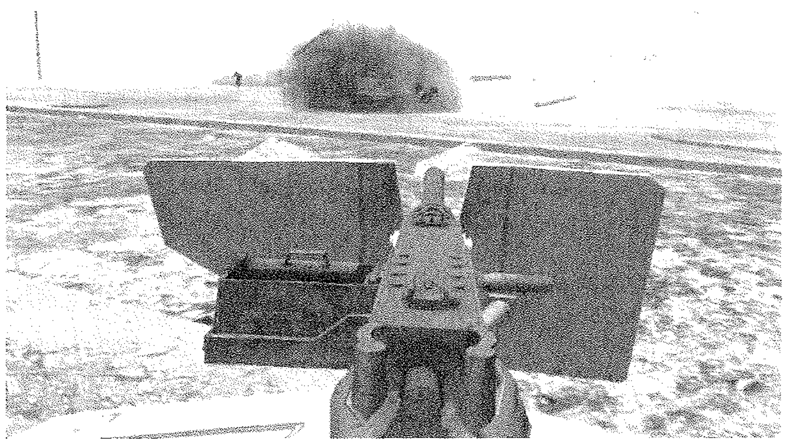

Figure 1. PTSD Convoy.

The immersive, interactive and realistic nature of CyberTherapy represents a promising intervention that has been documented as an exceptional treatment for Anxiety Disorders (i.e., Generalized Anxiety Disorder; Specific Phobias such as Acrophobia, Agoraphobia, Social Phobia, Arachnophobia, Aviophobia, Glossophobia; PTSD), pain management and rehabilitation [21 – 29; 36 - 38]. CyberTherapy overcomes many of the shortcomings of imaginal exposure by providing external visual and auditory stimuli for the patient, thus eliminating the need for intense imaginal skills. Cybertherapy permits a patient to interact with a virtual world, in a specific environment, in the safety and confidentiality of the therapy room [22 – 29, 36 - 38]. CyberTherapy works well for those with limited cognitive flexibility or imaginal capacity, stimulates the imaginal recall of the trauma, effectively "distracts" the patient experiencing pain and more fully engages the patient in physical and/or cognitive rehabilitation. When used with physiological monitoring, CyberTherapy can train the patient to reduce excess arousal in order to stay more fully engaged in the specific treatment [21 – 29, 36 - 38].

5. Research Utilizing Virtual Reality Exposure with Arousal Control (VRE-AC) for the Treatment of Combat-related PTSD

Exposure therapy is based on emotional processing theory (EPT), with the premise that fear-associated memories have been stored as a "fear structure" and include psychological and physiological information about stimuli, meaning and responses [39]. According to EPT theory, avoidance of internalized trauma or external reminders of the trauma serves to maintain the trauma symptoms [39, 40]. Exposure-based therapy, to treat PTSD, relies on patients using their imaginal recall to directly confront their fears by repeatedly "reliving" the traumatic event or events as fully as they are able to, as well as directly confronting their fears through "in-vivo" practice on a daily basis [40]. Once directly cognitively and emotionally engaged, the "fear structure" is open to modification through cognitive reprocessing, and over time results in extinction of the fear response and associated symptoms [27].

Although exposure-based therapies have been shown to be effective for the treatment of patients diagnosed with PTSD, including those patients diagnosed with PTSD secondary to motor vehicle accidents, combat, and those involved in the 9/11 World Trade Center attacks [21 – 29; 36, 38, 40], there is room for improvement [27, 28]. One hallmark of PTSD has been patients avoiding reminders of the trauma(s) [39] and because of this avoidance; many patients have been unwilling or unable to effectively visualize the traumatic event(s) during imaginal therapy [27]. Further, a great many patients are not able to engage in detailed visual imagery of their trauma, either because of emotional blocks or because they have limited imagery ability [29]. Cybertherapy or Virtual Reality-facilitated exposure therapy, has been shown to improve treatment efficacy for PTSD by combining VR-facilitated exposure therapy with arousal control (c.f., typically by training the patient in meditation, paced abdominal breathing and biofeedback), to achieve both improved physiological and psychological control, has been found to be of added value to exposure-based therapies [22 - 29, 36, 38].

Walshe's [38] virtual reality exposure program for patients with motor vehicle related PTSD utilized heart rate monitoring to provide physiological feedback to the patient and to the therapist during the session. The patient's physiological feedback was found to be an indication of reduced difficulties with PTSD during the course of treatment. Walshe et al [38] found that the patients' participation in an arousal control based VR-facilitated exposure program resulted in significant reductions in driving phobia severity, PTSD and heart rate.

In one of the first research investigations examining the effects of Cybertherapy or Virtual Reality Exposure with Arousal Control (VRE-AC) with OIF/OEF combat veterans, VRE-AC was utilized with 12 male active duty service members diagnosed with combat-related PTSD [41]. The presence of PTSD was confirmed during a standardized psychiatric examination performed by a Navy psychiatrist prior to the initiation of VRE-AC and the extent of PTSD was assessed following each combat veteran having completed a PCL-M. Following these 12 active duty service members having completed 10 sessions of VRE-AC, their scores on standardized measures of PTSD and Depression significantly decreased. The average duration of PTSD, for these service members, was 14 months before beginning VRET-AC.

The VRE-AC was delivered, to these service members, in 90 minute sessions over a 10-week period, with treatments being offered one to two times per week. The arousal control aspect of VRE-AC involved initial and ongoing training in mindfulness based meditation, biofeedback with paced abdominal paced abdominal breathing and awareness of and increased control over heart rate, skin conductance and peripheral temperature, and attentional refocusing for being more fully absorbed in the moment at hand [24]. In a recently published report, Wood et al [26] described successful Virtual Reality Graded Exposure Therapy for the treatment of combat-related PTSD with an active duty female Seabee who had completed three tours of duty in Iraq. Following 20 sessions of VRGET, this patient's symptoms severity decreased from diagnostic levels to non-diagnostic levels on measures of PTSD (CAPS), depression (PHQ-9) and anxiety (BAI). Intriguing, at the end of this Seabee's first 10 sessions of VRGET, she mentioned that, "I wished I had this (Cybertherapy) training prior to my first combat deployment or between my combat deployments"! Moreover, she elaborated, "I don't think that my PTSD difficulties would have been as bad if I would have had this treatment before or between my combat deployments" [26]. Due to the fact that the full results of the VRGET treatment are still pending, the outcomes of the analysis of the self-report and clinician- rated measures and the clinical psychophysiological measures' assessment and the VRGET outcomes cannot be presented at this time [26].

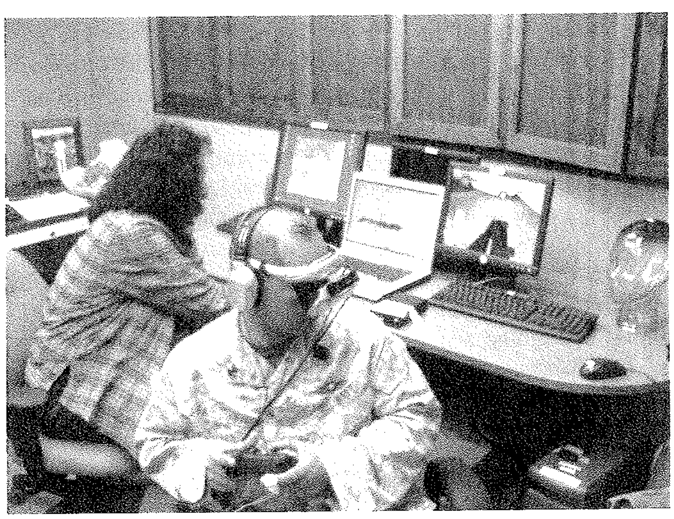

Figure 2. Non-patient patient undergoing VRET-AC.

6. Cybertherapy and Pain Management

Similar to the use of VRE-AC for the treatment of combat-related PTSD and other anxiety disorders, Cybertherapy or Virtual Reality Therapy for pain management relies on innovative computer software, including biofeedback, and a head-mounted display (HMD) to immerse the patient into a virtual environment. Instead of relying on an "exposure therapy" model as is utilized in the treatment of PTSD, VR for acute and chronic pain management utilizes a distraction model that allows patients to focus their attention away from both the painful sensation and their distressful reaction to it [25]. Virtual Reality (VR) has been effective for patients undergoing burn wound care, wound dressing changes, chemotherapy, dental procedures venipuncture and surgery [25, 43 - 50]. Virtual Reality has also been used in small trials for those with fibromyalgia and other chronic pain conditions [25].

When training in arousal control, with the assistance of biofeedback, meditation and paced abdominal breathing, embedded into the virtual world, patients with acute or chronic pain can learn skills that assist them once they leave the virtual world.

Hoffman and his colleagues [43, 44] have led mental healthcare to new frontiers by investigating the use of VR to assist patients to better manage burn pain. Hoffman et al (43, 44) created an immersive and interactive computer-simulated environment, called SpiderWorld, that was "viewed" by burn patients through a HMD and the patients could "pick-up" and manipulate virtual objects with their cyberhand. Hoffman et al [43, 44] found that VR significantly decreased the amount of pain reported, VR decreased the amount of time burn patients spent thinking about their pain during physical therapy and VR also contributed to a reduction in the anxiety reported by the burn patients during their physical therapy. Wiederhold & Wiederhold [25] commented that the results obtained by Hoffman et al [43, 44] provided preliminary support that VR can act as a strong nonpharmacologic pain reduction method for adult burn patients.

More recently, Manni et al [45] added a VR intervention (i.e., Snow World) to the usual pain medications in order to reduce excessive pain during wound care of combat-related burn injuries in two soldiers at Brooke Army Medical Center (BAMC). One soldier/patient had suffered 3rd degree burns on 32% of his body during a roadside bomb terrorist attack in Iraq; the other soldier/patient suffered 2nd and 3rd degree burns when his Humvee was hit by a terrorist's rocket propelled grenade in Iraq. During their wound care debridement, the soldiers/patients reported: (a) less pain when distracted with VR; (b) less "time spent thinking about pain" (reducing from 100% of the time during no VR to 15% of the time during VR for the first soldier and from 100% to 0% for the second soldier); (c) reduced "pain unpleasantness" (falling from a "moderate" 6 out of 10 to a "mild 4 out of 10 for the first soldier, and from 8 out of 10 to 2 out of 10 for the second soldier); and (d) reporting that wound care was "no fun at all" 0 out of 10 during no VR to a "pretty fun" 8 out of 10 during VR for the first soldier and from 0 out of 10 to 10 out of 10 for the second soldier). Manni et al [45] suggested that "an immersive VR can be an effective adjunctive nonpharmacologic analgesic for reducing cognitive pain, emotional pain and the sensory component of pain of soldiers experiencing severe procedural pain during wound care of a combat-related burn injury".

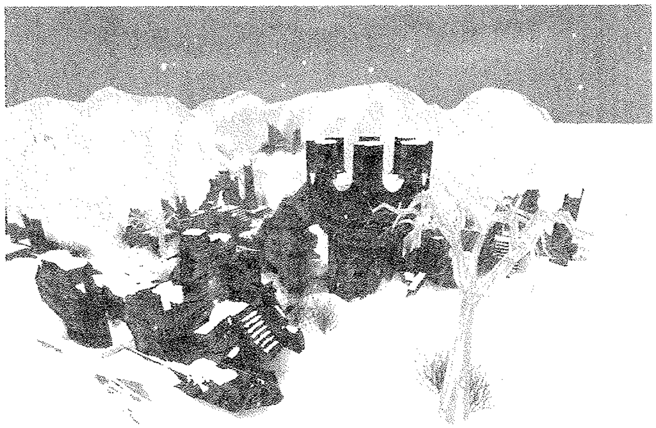

Figure 3. Snow World.

In researching the utilization of VR with elderly patients (age 75.8+/- 9.8 years) receiving superficial debridement and wound dressings for their leg ulcers, Tse et al [46] had patients alternate between viewing a static blank screen (B-Session) and wearing an eyeglass display with no sound but showing a visual content that was selected according to the preferences of the patients (V-Session). The V-Session visual content ranged from a Chinese opera to cartoons and natural environment of mountains and a waterfall. A significant reduction in pain scores was observed in the patients during the V-Session exposure versus the B-Session. Tse et al [46] concluded that their study was "a pioneer(ing) use of visual stimulation as a non-pharmacological adjuvant to pain relief among a local Chinese population."

VR has assisted with improving a cancer patient's ability to be distracted from somatic distress [47, 48]. Schneider [47] had 123 adult chemotherapy patients immersed in images of deep sea diving, walking through an art museum, exploring ancient worlds and solving the mystery of the Titanic. Eighty-six percent of the patients enjoyed the VR intervention and 82% of the patients would use the VR again during subsequent chemotherapy treatments. A significant number of the chemotherapy patients reported that they experienced a shortened perception of time and significantly less anxiety, making chemotherapy treatments more tolerable [47]. Cole et al [48], used a PC-based game, titled Re-Mission, which included fictional cancer patients, who were undergoing radiation, chemotherapy and immunotherapy, engaging in 20 different "missions". The cancer patients using this game-playing environment significantly increased their cancer-related knowledge, ability to manage chemotherapy side effects, increased self-efficacy to communicate about their cancer and reduced distress.

Wiederhold [25] reported that VR could effectively reduce levels of chronic pain. Patients were asked to rate their pain while not engaged in VR and while engage and navigating in the Icy Cool World, where they could move through various environments and engage in a variety of tasks. While navigating in Icy Cool World, the patients rated a significant decrease in their pain and anxiety ratings as compared to their pain ratings while not navigating in Icy Cool.

Figure 4. Icy Cool World.

Virtual Reality Medical Center has developed a VR pain distraction system (i.e., Enchanted Forest) to be use in the dental office as well [25]. This system was used with 10 dental patients that were being treated for replacement of crowns, fillings, root canals and cosmetic dental work. During the dental procedures, patient wore the VR HMD and viewed and interacted, using a joystick, with variety of VR environments. The patients' physiological signals including electrocardiogram, skin temperature, skin conductance and respiratory rate were also monitored by noninvasive sensors. Overall, the dental patients reported a reduction in the level of discomfort and pain while exploring the interactive virtual worlds. Additionally, the patients' skin temperature tended to increase from baseline during their procedures suggesting the presence of increased relaxation.

Lastly, Mosso-Vazquez et al [49, 50] utilized Virtual Reality Medical Center's VR system, including a HMD and headphones for sound, with 302 patients undergoing a variety of medical or surgical procedures. The VR system immersed patients in one of two virtual worlds: Enchanted Forest or Icy Cool World. These various medical or surgical procedures included: upper gastrointestinal endoscope, Colonoscopy, kidney transplant, coronary vessels revascularizations, cardiac valve replacements, umbilicus hernia repair, labor and delivery, Cesarean Section and epidural block. VR was utilized, during patients' ambulatory and obstetric surgeries and patients hospitalized in postoperative Cardiac and Nephrology care units. Reduced stress and pain were noted in all of the patients [49, 50]. The cardiac patients, within 24 to 48 hours post-surgery, reported a higher level of well-being while "immersed" in a VR world versus not "immersed" in a VR world (i.e., 7.25 vs. 3.12 on a scale of 1 – 10, 10 being the greatest amount of well being) [50].

7. Mixed Virtual Reality Therapy and Physical Rehabilitation Following Cerebrovascular Accident (CVA)

More than 795,000 Americans are diagnosed with stroke annually, costing the U.S. economy an average of $68.9 billion [51, 52]. Yet since the risk of stroke at age 55 is one out of six, with the risk of stroke doubling for every 10 years after age 55, the impact of a stroke on the American population is escalating rapidly as the population ages [51, 52]. More than 50% of stroke victims suffer from impairment of the upper limb, hindering their ability to carry out simple tasks related to activities of daily living [37, 51]. Recent evidence shows that intensive and repetitive rehabilitation, even a year after the cerebrovascular accident that leads strokes (CVA) can foster improve functionality in the patient's limb negatively affected by a stroke [37].

Traditional stroke rehabilitation programs optimally combine physical and cognitive rehabilitation [20]. Once released from in-patient status, patients are given exercises to do on their own (or with family members), and then they can engage in outpatient physical therapy, occupational therapy, speech therapy and cognitive rehabilitation. Yet even those fortunate enough to live near an outpatient stroke rehabilitation program, they must rely on daily self-help physical and cognitive exercises at some point during their outpatient course of treatment. One challenge for all rehabilitation is that after the initial period of recovery, patients prematurely plateau in their recovery. Related stroke rehabilitation challenges include low levels of interest and participation in rehabilitation because of the nature of the self-help exercises, which are not interesting, engaging or repetitive [37, 51]. Even within a stroke rehabilitation setting, it is difficult to train patients in many aspects of activities of daily living (i.e., dressing, picking up objects, preparing meals, personal hygiene, etc.), or in job retraining, since those environments cannot easily be replicated in the rehabilitation setting.

A novel use of Cybertherapy is for stroke rehabilitation [51]. More recently, Mixed-Reality Cybertherapy for cognitive and physical rehabilitation or The Mixed Reality Rehabilitation System (MRRS) has been developed [37, 53]. Henderson et al [51] concluded that immersive VR may have an advantage over no therapy in the rehabilitation of the upper limbs in patients with stroke. The fully immersive VR system can use large screen projection (LSP), head-mounted display (HMD), or cave (BNAVE) system to project a virtual environment onto a concave surface to create a sense of immersion or real-time involvement with the rehabilitation or training environment [51]. While Henderson et al [51] did not describe the content of the VR training environments, outcomes from VR rehabilitation resulted in an increase of 11% in unilateral dexterity, bilateral dexterity also increased by 22% and grip strength increased 44%.

The physical and cognitive rehabilitation MRRS prototype was designed and built by The Virtual Reality Medical Center and the Institute for Simulation and Training at the University of Central Florida [37, 53]. The MRRS prototype extends VR by blending real and virtual worlds into a seamless landscape. Patients in MR treatment wear a Visual See-Through Head-Mounted Display (VST-HMD) versus a HMD that allows them to see a virtual environment blended into their view of the real environment-effectively "mixing" the two realities. For example, while immersed in MRRS, you can see your actual hands interacting with some real object (i.e., steering wheel of a fork lift, fax machine, supplies on a work bench, cooking utensils, clothes in a dresser, contents of your wallet, keys on a computer keyboard, coffee cup, etc.) but in a virtual world (i.e., driving on the freeway, working in a warehouse, preparing a meal in a kitchen, dressing, completing home chores, working on an assignment needing a computer, etc).

The principal advantage of MRRS is that it creates an altered or augmented reality without loosing the benefits of an actual physical setting for purposes of cognitive and physical rehabilitation. Thus, MRRS can blend the senses with other humans or specific items that one needs to re-learn to interact with in activities of daily living or specialized work settings.

The MRRS was developed to overcome many of the deficits in traditional rehabilitation therapy by providing an interactive, engaging or "immersive" rehabilitation tool that patients would want to use. Additionally, in order to measure "immersion" and the "stress" associated with involvement in the MRRS therapy, one of the PCs is utilized to measure peripheral psychophysiology, including heart rate, skin conductance, peripheral temperature and breaths per minute. In a recently completed pilot study, 14 healthy patients, ages 18 to 63 years old, participated in MRRS therapy trials [37]. Engagement, workload and distraction levels were measured while the patients performed tasks in the MR environment. Planned distracters common to an office or work setting (e.g., noise of machines, a ringing phone, faxes being printed on a fax machine, announcements on an overhead speaker, etc) were employed during a rehabilitation task (e.g. the need to physically move boxes from one section of a counter top to another section of a counter top) – all within the MRRS scenario. Thus, various levels of distraction could be employed to approach "ecological validity" - the way such tasks need to be performed in the real world. Comparing patients' physiological arousal at baseline to their higher physiological arousal, while engaged in the MRRS scenarios, allows an appreciation of the degree of effort being utilized to perform a task, something that can be useful to clinicians as they "titrate" the therapy.

Study patients reported that the MRRS scenarios were engaging and provided an interactive experience. Salva et al [37] concluded that initial trials with MRRS seemed to suggest that it has many capabilities and great potential to extend rehabilitation services to patients who have suffered a CVA. The extension of rehabilitation services are due to the fact that the patient becomes engaged while involved in MRRS. Additionally, the MRRS environment is safe, which allows patients to explore the MRRS without feeling as though they are threatened. Lastly, in both cognitive and physical rehabilitation, an advantage over the real world included the fact that the MRRS can be manipulated in ways extending beyond the real world [37].

8. Conclusion

Several reports have documented that 25% of the 1.64 million U.S. troops deployed to support the War on Terrorism operations in Afghanistan and Iraq, since October 2001, have met criteria for either PTSD or depression [14 - 16]. Further, reports have estimated that the rate of PTSD will be higher among troops who have been to Iraq more than once [14, 54 - 56]. Utilizing the 25% incidence of PTSD or depression of those deployed in addition to the 2 million men and women having completed combat deployments to Iraq and Afghanistan then 500,000 of these warriors could meet the criteria for either PTSD or depression according the recent Department of Defense data [57].

Various VHA PTSD treatment programs have been established [1, 7 - 10] and positive steps have been taken [58] to respond to the recommendations made by the Presidents Commission [15]. Also the DOD Task Force [16] reports that only 30 to 53% of returning OIF and OEF veterans, who met criteria for PTSD or major depression, have sought help from a provider for these diagnoses [14, 56, 60]. Numerous reasons have been suggested as to why more OIF and/or OEF veterans have not sought treatment for their combat-related PTSD and depression. These reasons have included not only the concept of stigma, but also a fear that seeing mental health treatment "would harm my career" [14, 55, 56, 59, 61]. An additional reason why OIF and/or OEF veterans have not sought mental health interventions at the VHA may have to do with the finding that 72% of VHA psychologists "were not comfortable" with utilizing imaginal exposure therapy for the treatment of PTSD due to several beliefs, including the belief that exposure treatment may increase patients' fears and anxiety to dangerous levels, ultimately worsening symptoms [14]. To address this "fear", Tanielian and Jaycox [14] recommended that the VHA develop clinical and training strategies that would "increase and improve the capacity of the mental health care system to deliver evidence based care" to OIF and OEF veterans. However, an inescapable reality is that an estimated 70% of returning OIF/OEF veterans who suffer from depression and PTSD will not seek help from the Department of Defense or the VHA. Insel [55, 60] has warned that this inescapable reality is a "gathering storm" that looms over civilian psychiatric care.

Cybertherapy is a compelling, therapeutically effective, safe and immersive virtual environment that has been successfully developed for a PC-platform that could assist with increasing and improving the capacity of a mental health care system to deliver "evidence-based care" to OIF and OEF veterans diagnosed with combat-related PTSD. The Cybertherapy PC-based system is both clinician and patient friendly and can be implemented by skilled clinicians with appropriate training in imaginal exposure therapy.

Seventy-five percent of patients in a VA pain clinic receiving opioid treatment, report an average pain rating of between 6.35 and 7.44 out of 10.There have been recommendations suggesting that VA pain clinic patients should be assessed and managed differently [4] compared to non-pain patients. Cybertherapy has the potential for achieving substantial relief in pain and other somantic symptoms. Cybertherapy allows the patient to interact with the virtual environment, using many of their senses and encourages the patient to become immersed in the virtual world they are experiencing. When immersion is high, much of the patient's attention is focused on the virtual environment; leaving less and less attention to focus on other stimuli or sensations, such as the cause of the pain or pain itself.

While the VHA has devoted over $1 billion annually for stroke-related costs, including those costs associated with specialized stroke rehabilitation, the VHA continues to remain concerned about those patients who experience recurrent strokes and the fact that equipment for home health rehabilitation, of stroke patients, is limited [5,6, 20]. The Cybertherapy/MRRS therapy currently includes protocols for safe and successful physical and cognitive rehabilitation. MRRS can measurably improve the outcome of physical and cognitive rehabilitation during all phases of rehabilitation, including during the acute hospitalization, the post-acute stroke care/rehabilitation and the home health rehabilitation phases.

We have presented an overview of research and clinical practice involving the use of Cybertherapy that has demonstrated the capacity to contribute to the reduction in the severity of combat-related PTSD and the reduction of pain during various medical procedures as well as early research with Cybertherapy has indicated that it has many capabilities to extend services offered to individuals during stroke rehabilitation. Successful immersion and distraction by using Cybertherapy has been shown to be well accepted and often preferred by many patients. While the management and successful interventions for patients diagnosed with combat-related PTSD, chronic pain or a stroke requires a multidisciplinary team of clinical experts, the addition of

Cybertherapy to a clinical expert's armamentarium can add a unique and "leading edge tool" that can assist in not only the improvement of treatment outcomes but also the improvement in the patients' participation with treatment and their improved satisfaction from treatment.

Lastly, Wiederhold and Wiederhold [25] have encouraged that research should be pursued in order to provide a growing understanding of the mechanisms underlying the effectiveness of Cybertherapy for the successful treatment of PTSD, chronic pain and stroke so that improvements and/or more specific virtual environments can be created that are linked to specific types of psychological and/or physical conditions. More studies are needed to examine the improved efficacy of Cybertherapy and other virtual technologies that can further improve positive treatment outcomes for PTSD, chronic pain and stroke and to explore the feasibility of porting this technology to personal PCs, and laptops, smart phones and cell phones [25, 30 - 35]. With Cybertherapy software on personal PCs or laptops and on smart phones or cell phones, patients would have access to Cybertherapy on an "anytime, anywhere" basis contributing to the improved quality of life and well-being for patients.

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