Graduate Student Journal of Psychology
2015, Vol. 16

An Exploratory Study of Posttraumatic Stress Disorder, Sleep Disturbances, and Executive Functioning in Veterans

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Introduction: Hypervigilance, hyperarousal, and sleep disturbances are components in the diagnosis and treatment of Posttraumatic Stress Disorder (PTSD) and other trauma-related diagnoses. The current study explores the relationships between PTSD, sleep, and executive functioning among military veterans. Method: The Immediate Post-concussion Assessment and Cognitive Testing Battery (ImPACT) is utilized to examine the cognitive performance of 18 veterans. Dependent measures included composite scores of verbal memory, visual memory, processing speed, and reaction time from the ImPACT computerized test battery, as well as total symptom scores from the Clinician Administered PTSD Scale (CAPS), the Pittsburgh Sleep Quality Index, and the Pittsburgh Sleep Quality Index – Addendum for PTSD (PSQI-A). Results: Veterans showed significant deficits in verbal memory and slower reaction times relative to normative data. The veterans did not differ from the normative group on visual memory and processing speed indices. After adjusting for sleep disturbances, reaction time remained significantly correlated with PTSD symptom severity in veterans. Conclusions: Executive functioning deficits in verbal memory and reaction time are detectable in veterans who endorse clinical and subthreshold symptoms of PTSD.

Trauma and the Military

Researchers have estimated that 50-60% of individuals will experience a type of serious trauma (via military combat, sexual assault, perceived horror or threat, or another major accident) during their lifetime. Additionally, 5-10% of individuals have been estimated to develop symptomology which qualifies them for a clinical diagnosis of Posttraumatic Stress Disorder (PTSD) (Aupperle, Melrose, Stein, & Paulus, 2011). Furthermore, Aupperle et al., have suggested that neuropsychological approaches to research, which address the frontal lobe or executive function/dysfunction, may offer additional insight regarding cognitive processes that could potentially be affected by traumatic events and PTSD. To date, much of the research has focused on learning and memory, which may not necessarily have the same impact on PTSD susceptibility, resiliency, and development as executive functioning.

The prevalence of traumatic brain injury (TBI), its relationship to veterans diagnosed with PTSD, and its impact on frontal lobe or executive functioning is also a presently debated topic. Data from a Veteran Affairs Polytrauma Rehabilitation Facility involving OEF/OIF Veterans receiving care was studied in which the VA research group compared combat-related TBI (74%) to noncombat TBI (71%). Veterans with combat-exposed TBIs reported higher sleep disturbances (>50% vs. <30%) and symptoms of acute stress reaction or PTSD (Taber & Hurley, 2010).

The conflicts in Afghanistan (Operation Enduring Freedom [OEF]) and Iraq (Operation Iraqi Freedom [OIF]) have resulted in the highest rates of military troop mobilization and deployment since the

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Vietnam War (Gewirtz, Polusny, DeGarmo, Khaylis, & Erbes, 2010). An exceptional amount of reliance is also being placed on National Guard/Reserve (NG/R) groups. Service members returning from OEF/OIF have been shown to be at greater risk for developing or presenting with mental health issues (Frueh, Grubaugh, Elhai, & Buckley, 2007). Specifically, TBI, PTSD, and Major Depressive Disorder are distinct post-combat health outcomes (Ozer, Best, Lipsey, & Weiss, 2003). Additionally, research revealed self-reports from the NG/R troops of mental health issues (depression, relational issues, and PTSD) are more than double those of active duty service members (42.4% versus 20.3%). NG/R troops also double the amount of mental health issues regarding (PTSD) screenings both post-deployment (12.7%) and 6 months thereafter (24.5%) when compared to active duty service members (Gewirtz et al, 2010). Statistics collected by Gewirtz et al., (2010), regarding active duty troops versus NG/R troops, supports ongoing research efforts which hypothesize that non-combat exposed veterans face similar traumatic and psychological risks to combat-exposed veterans.

Importance of Executive Functioning

Executive functioning is a set of mental processes that helps connect past experience with present action. Individuals use executive functioning to perform activities such as planning, organizing, strategizing, paying attention to and remembering details, and managing time and space (Aupperle, Melrose, Stein, & Paulus, 2011). Individuals with executive functioning deficits may also have a weakness with their working memory. Working memory is the ability to actively maintain and manipulate information of one's mind over a short period of time. Working memory is an important component of executive functioning, and is typically affected following a traumatic event due to the quick task demand that is necessary to encode, retrieve, and manipulate various stimuli while functioning in daily life (Aupperle et al., 2011). Samuelson et al (2006) noted that decreased performance on measures of working memory have been found in combat- and sexual assault- related PTSD when compared to victims without PTSD and non-trauma controls. Furthermore, working memory is needed to transfer information to long-term memory. When working memory is impaired, the process of transferring information is likely to be impaired as well (Brenner et al., 2010).

Verbal memory refers to the memory of words and other abstractions of language, while visual memory describes the relationship between perceptual processing and the encoding, storage, and retrieval of the resulting neural representations (Apperle et al., 2011). Reaction time, also referred to as 'mental chronometry,' is the use of response time in perceptual-motor tasks to infer the content, duration, and temporal sequencing of cognitive operations. Processing Speed is one of the measures of cognitive efficiency or cognitive proficiency. It involves the ability to automatically and fluently perform relatively over-learned cognitive tasks, especially when high mental efficiency is required (Strauss, Sherman, & Spreen, 2006). PTSD effects memory recall and accuracy (Lezak, 2008). While PTSD affects various areas of executive functioning, it has been shown to most significantly affect verbal memory (Strauss, Sherman, & Spreen, 2006). Researchers have indicated that verbal memory impairment is found to be the most consistent cognitive impairment related to PTSD. Verbal memory has also been shown to be a specifically pronounced deficit in comparison to visual memory or processing speed in individuals diagnosed with PTSD (Johnsen & Asbjornsen, 2008).

Short-term memory is another processes involved with working memory. Short-term memory is needed for disposal, integration, processing, and retrieval aspects of memory functioning to ensure the working memory aspect of the cognitive process is effective (Turner, Salamat, Drummond, & Brown, 2007). In the general population, the executive functioning component involved with working memory elicits a controlled response to stimuli (e.g., impulse control). In individuals diagnosed with PTSD, executive functioning may be compromised. Individuals with PTSD may respond to stimuli with hypervigilance, hyperarousal, and impulsivity (Turner et al., 2007). Individuals with PTSD may have difficulty with an inability to consolidate memories due to trauma, which is also linked to increased autonomic arousal and inhibition of the hippocampus (Aupperle et.

al., 2011). Executive functioning deficits are likely to affect the daily functioning of individuals with PTSD, and may also play a prominent role in sleep patterns and nightmare production (Levin & Nielsen, 2007).

Neurobiological Aspects of Nightmares

Nightmares are a core re-experiencing feature of PTSD. Nightmares are clinically defined as "intensely disturbing dreams that awaken the dreamer to a fully conscious state and generally occur in the latter half of the sleep period" (Hasler & Germain, 2009, p. 2). As many as 90% of trauma-exposed individuals who develop PTSD report disturbing dreams that bear varying degrees of resemblance to the actual traumatic event (Oscar et al., 2010). Additionally, dream-related disorders such as posttraumatic dreams, nightmares, bad dreams, and recurrent dreams are the most frequently reported and most persistent symptoms exhibited by trauma victims (Kobayashi, Boarts, & Delahanty, 2007). According to Stickgold (2005), explicit Rapid Eye Movement (REM) sleep models of the neurobiological states of nightmares potentially provide emotional processing and integration of trauma-related memories. REM sleep provides a unique neurobiological state that allows for the transfer of hippocampus-mediated episodic traumatic memories and related amygdala-dependent affect into the cortically distributed semantic networks of the brain. The amygdala is hyperreactive to traumatic images during the sleep cycle in persons with PTSD, which then produces a nightmare as a response to the threat-related stimuli, thus interfering with the transfer of traumatic memories to higher cortical areas (Germain & Zadra, 2009).

A meta-analysis of 20 PTSD studies by Kobayashi (2007) found that difficulties falling or staying asleep were reported by 44%-90% of veterans with PTSD, and that 52%-87% reported having recurrent nightmares. Additionally, a recent study was completed in which 304 of 316 veterans reported combat-related nightmares (Germain & Zadra, 2009). Over half of the veterans in this sample reported realistic combat dreams, 21% reported conceivable war sequences they had not actually experienced, and 26% reported dreams that mention or relate to the war, but also included fantasy and everyday factors. Furthermore, only 21% of the dreams reported by veterans in the study were precise replications of their experienced traumatic event, while the majority of dreams contained contrived distortions related to the traumatic event.

The current study explores the relationships between PTSD, sleep, and executive functioning.

Hypotheses

The presence and severity of PTSD symptoms was assessed by the Clinician Administered PTSD Scale (CAPS), and executive functions were assessed by different modules of The Immediate Post-concussion Assessment and Cognitive Testing (ImPACT), and results were compared to norms from age and sex-similar groups. The hypotheses were (1) that the overall participant group, exhibiting varying symptom severity, would score lower on visual memory, verbal memory, reaction time, and processing speed domains compared to normative values; (2) veterans with PTSD would show greater impairments than veterans without PTSD on the ImPACT domains when respectively compared to the normative group; and 3) the relationship between PTSD severity and executive dysfunctions would remain significant after adjusting for the severity of sleep disturbances.

Method

Participants

Between January 2011 and January 2012, participants were actively recruited though media advertising in a northwestern metropolitan area. Participants were combat-exposed military veterans diagnosed with Posttraumatic Stress Disorder (PTSD) ($n = 11$) and without PTSD ($n = 7$), all of whom had self-reported nightmares or nocturnal sleep disturbances. Fifteen participants were male and three were female between the ages of 18 and 50 years old ($M = 24$ years, $SD = 2.4$). The racial/ethnic composition of the participants was fairly homogenous with fourteen participants identifying as Caucasian, three as Asian-American, and one as African-American. Participants were assessed via a detailed screening process as part of a concurrent sleep study. Veterans were excluded if they were over 55 years of age, or if they had been excluded from the initial study due to medical conditions or medication known to affect sleep.

Measures

As a part of the parent study, participants also completed the Clinician-Administered PTSD Scale (CAPS; Blake, Weathers, Nagy, Kaloupek, Gusman, Charney & Keane, 1995), the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman & Kupfer, 1989) and the Pittsburgh Sleep Quality Index Addendum (PSQI-A; Germain, Hall, Krakow, Shear, & Buysse, 2005). The Clinician-Administered PTSD Scale (CAPS) is a structured interview that measures severity of symptomology and diagnosis of PTSD. The CAPS assesses the frequency and intensity of seventeen symptoms using standard questions and behaviorally anchored rating scales. Questions include assessing for nightmares associated with PTSD. The CAPS is considered to be the gold standard in PTSD assessment (Blake et al., 1995). The inter-rater reliability of the CAPS is high, ranging from 0.92 to 1.00 for "Frequency" and 0.93 to .98 for "Intensity" ratings with the global severity correlation equating 0.89. The CAPS test-retest reliability ranges from .77-.96 for the three symptom clusters and from .90-.98 for the 17-item core symptom scale (Blake et.al, 1995).

The Pittsburgh Quality Sleep Index (PSQI) was employed as a measure of disturbing nocturnal behavior (sleep disturbances). The PSQI has ten questions, and is a fill-in-the blank questionnaire. The PSQI was developed to qualitatively measure sleep quality during the previous month. The instrument also discriminates between good and poor sleepers. The PSQI has a global score correlation coefficient for test-retest reliability of (.87). Similarly, The Pittsburgh Quality Sleep Index Addendum (PSQI-A) is a self-report instrument designed to assess the frequency of seven disruptive nocturnal behaviors (DNB) or sleep disturbances commonly associated with PTSD.

Participants completed the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT), which is a computerized neuropsychological test (Iverson, Lovell, & Collins, 2003).

The ImPACT measures several executive functioning composite index scores. This study made use of four: Verbal Memory, Visual Memory, Processing Speed, and Reaction Time. The composite scores are made up of six modules designed to test verbal recognition, visual memory, processing speed, impulse control, and working memory.

Intraclass correlation coefficients for the ImPACT include processing speed (.85), reaction time (.76), visual memory (.70), and verbal memory (.62) (Elbin, Schatz, Covassin, 2011). Resch et.al (2013) compared two performance groups, with the second group also completing a test of effort. The researchers found that composite score intraclass correlation coefficients ranged from .26 to .88 for the 4 scores in Group 1 and .37 to .76 in Group 2.

For the current study, data was automatically scored with the computerized structure within the ImPACT, which provided composite scores for each category (Verbal Memory, Visual Memory, Processing Speed, and Reaction Time). The ImPACT generated the particular composite scores for the present study by comparing scores from university male participants to individuals in the overall normative sample, and provided composite scores. The primary populations studied for ImPACT research are typically that of sports-related injuries, which superficially appeared to differ from our sample of combat-exposed injuries. However, the ImPACT has been investigated within the military population and yielded a .80-.89 test-retest reliability score (Cole et al., 2013). Individuals in the PTSD group met full diagnostic criteria for symptomology as indicated by the CAPS. The nPTSD group, while self-reporting some symptomology, did not reach criteria threshold for a clinical diagnosis of PTSD. The two veteran groups were separately compared to the normative sample from the ImPACT.

Procedures

One-sample t-designs were used to analyze the composite scores of each subtest score generated from the ImPACT, and were then compared to the mean composite score of the normative sample. The chosen comparison was used due to none of the participants in the current study presenting completely free of symptomology and therefore, they were unable to be utilized as part of a control group. Further, the normative group from the ImPACT used for comparison was comprised of university males, which was the group which most closely matched the current study's participant sample. While not ideal, the limitations with power and sample size were recognized and results were interpreted with caution.

The ImPACT was administered via computer by the primary investigator while being supervised by a Ph.D. clinician, the primary investigator of the concurrent sleep study. Participants were informed the study was in partial fulfillment of a doctoral dissertation. The participants navigated through six modules. The ImPACT took approximately thirty to forty-five minutes to administer. When the ImPACT concluded, participants were afforded time to ask questions, as well as given debriefing sheets.

Results

The ImPACT computer-generated printout provided descriptive statistics for each composite score based on their overall normative group of university students. Verbal memory composite score ($M = 88.2$, $SD = 12.4$), Visual Memory composite score ($M = 72.3$, $SD = 14.9$), Processing Speed composite score ($M = 35.6$, $SD = 8.3$), and Reaction Time composite score ($M = 0.58$, $SD = .12$) averages and standard deviations were all provided to the investigators.

H_1: The entire sample of veterans showed statistically significant impairments compared to the normative data for IMPACT, on the verbal memory composite score (t (17) = -2.737, p = .014; M = 81.72). Reaction time composite scores among participants were also slower than normative data, t (17) = 2.837, p = .011; M = .61.

H_2: The verbal memory composite score was significantly lower in veterans with PTSD (t (11) = -3.001, p = .013; M = 78.73), but not in veterans without PTSD t (6) = -.658, p > .05, M = 86.43. Each group was compared to the ImPACT normative group, respectively. Further, when compared to the ImPACT normative group, individuals diagnosed with PTSD had significantly slower reaction times t (10) = 2.610, p = .026; M = .62, indicating they responded less quickly to tasks that were constructed to measure speed and efficacy. In comparison, veterans without PTSD responded as quickly as the normative sample t (6) = 1.224, p > .05; M = .59. Both visual memory and processing speed had non-significant findings in the overall sample group (t (17) = -.948, p > .05; M = 74.72 and t (17) = -.946, p > .05; M = 35.22), when compared to the ImPACT normative group. Additionally, the PTSD group had non-significant findings t (10) = -1.070, p > .05; M = 73.28 and t (10) = -2.229, p > .05; M = 32.36 when compared to the ImPACT normative group, as did the PTSD group t (6) = -.148, p > .05; M = 77.00 and t (6) = .650, p > .05; M = 39.72 when compared to the ImPACT normative group.

H_3: Lastly, results indicated that verbal memory and reaction time were significantly correlated with the PSQI-A (r = .033, p = < .05) and (r = .031, p = < .05), respectively, when adjusting for sleep symptom severity.

Conclusion

The results of the current study coincide with existing research regarding verbal memory impairments in individuals diagnosed with PTSD. The term verbal memory encompasses both encoding and retrieval of information. Verbal memory is necessary for the processing of traumatic memories when considering hyperarousal and the inability to quickly encode and retrieve responses concerning external stimuli (McClincy, Lovell, Pardini, Collins, & Spore, 2006). Difficulty with encoding and processing visual stimuli can lead to increased or prolonged hyper-aroused states, increased physiological responses (high blood pressure), and other psychological symptoms such as increased levels of anxiety (Frueh, et al., 2007). Reaction time appears to be another area of functioning affected in individuals with PTSD symptompology. Research has suggested that individuals diagnosed with PTSD, or individuals with symptoms related to traumatic memories, have slower reaction times, which could be a vicarious consequence of decreased executive functioning (Johnsen & Asbjornsen, 2008). Decreased reaction time can lead to slowed response to external stimuli, reduced agility in response to physical responsibilities, and possibly psychomotor slowing while addressing cognitive tasks in employment or academic settings (Aupperle et al., 2011).

Commonly, traumatic nightmares are among the most treatment-resistant symptoms of PTSD. When utilizing sleep as a correlative variable in the equation, verbal memory and reaction times appeared to be non-affected in individuals with and without a diagnosis of PTSD. It could be suggested that sleep disturbances can decrease verbal memory and reaction time; however, one could also infer that by increasing executive functioning (i.e., strengthening verbal memory and reaction time via neurocognitive therapeutic interventions), sleep disturbances may decrease and vice versa. This is particularly concerning within the veteran population as they are more likely to underreport psychological symptoms than the general population, which could arguably be due to the military culture and training (Port, 2001).

Within the general population, executive functioning that is involved with working memory elicits a controlled response to stimuli. Research has suggested that individuals diagnosed with PTSD are more likely than the general population to have compromised executive functioning (Aupperle et al, 2011) (Johnsen & Asbjornsen, 2008). Individuals with PTSD may also have difficulty consolidating memories due to deficits in working memory, which is also linked to increased autonomic arousal and inhibition of the hippocampus (Aupperle et. al., 2011). Thus, executive functioning deficits are more likely to effect the daily functioning of individuals with PTSD than the general population, and may also play a prominent role in sleep patterns and nightmare production (Levin & Nielsen, 2007).

Limitations

The primary limitation to the study was the homogeneity of the sample, as well as the sample size. While we were able to obtain some significant results on two composite scores with a small sample size, a larger sample would have allowed us to make further inferences, particularly when examining the relationship with sleep disturbances. Obtaining some significance is encouraging for future research, when a larger sample may be possible, as well as a more gender, ethnically diverse sample. This could be sought in future studies in order to provide a broader understanding of how sleep and executive functioning may affect different sociocultural groups within the veteran population.

Directions for Future Research

The study aspired to determine if there was a relationship between PTSD, sleep, and executive functioning. While there was a power differential and our results were interpreted with caution, the findings do suggest a link between some aspects of executive functioning, which will likely affect individuals with PTSD symptoms. Results also suggested verbal memory and reaction times are unaffected by sleep disturbances.

Future research could include the implementation of an intervention, in a test-retest model, for veterans who are experiencing the aforementioned symptoms. The determination of executive functioning impairments could be measured via broad assessment and evaluation protocols (Bromberg, 2003; Rutherford et al., 2010). Rather than the unaccompanied treatment of the psychological symptomology of PTSD with primarily trauma-based therapeutic interventions, the addition of a neurocognitive therapeutic intervention could be beneficial if there were present executive dysfunctions to consider.

Research has suggested that a multi-modal approach may be more efficacious in the treatment of co-occurring PTSD and neurocognitive dysfunction (Davidson & Frances, 1999); although, at this time, there is not a substantial amount of literature that provides empirically based approaches to this ideation. While Aupperle and colleagues (2011) validated that increased neuropsychological research is needed to identify the effects of treatment on cognitive function and to potentially characterize mechanisms of current PTSD treatments, the ability to identify areas of focal deficits is a step closer than researchers have been in the recent past. The option of providing a different type of treatment opportunity to the civilian and military populations could potentially increase their quality of life and afford individuals more opportunities regarding interdisciplinary treatment and options.

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