RESEARCH ARTICLE

Insomnia Severity, Combat Exposure and Mental Health Outcomes‡

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Abstract

Few studies have examined insomnia severity as a moderator of the impact of combat experiences on posttraumatic stress disorder (PTSD) and alcohol problems, such that combat exposure is expected to have more negative consequences for soldiers who report insomnia. In this study, a sample of 522 military personnel completed measures of PTSD and alcohol problems prior to a 12-month deployment to Iraq, and then completed measures assessing insomnia severity, combat exposure, PTSD, alcohol problems and overall distress 3 months post-deployment. Results of a moderated multiple regression indicated that insomnia severity interacted with combat exposure to predict PTSD and alcohol problems after controlling for pre-deployment baseline measures of these outcomes, such that the relationship between combat exposure and the mental health symptoms was stronger when insomnia severity was greater. Results are discussed from the perspective of the role of insomnia in the development of PTSD and alcohol problems, as well as from an occupational health perspective where insomnia may deprive individuals of the resources they need to recover from the effects of severe occupational stressors found in high risk occupations. Published in 2010 by John Wiley & Sons, Ltd.

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Introduction

Researchers have recognized the important role of sleep in psychological functioning (De Koninck, 1997). The quantity and quality of sleep predicts cognitive performance (see Pilcher & Huffcutt, 1996; Wesensten, Belenky, & Balkin, 2006), as well as psychological and physical health (Barton, Spelten, Totterdell, Smith, & Folkard, 1995; Dolan, Adler, Thomas, & Castro, 2005; Naitoh, Kelly, & Englund, 1990). In the present research, we suggest that insomnia deprives individuals of a critical resource needed to perform psychological tasks and as such, may affect recovery following exposure to combat-related traumatic events.

Although the relationship between combat and post-deployment mental health outcomes is well-established by large-scale epidemiological studies (Hoge et al., 2004; Milliken, Auchterlonie, & Hoge, 2007; Thomas et al., 2010), and rates of mental health problems have been found to increase in the months following deployment (Bliese, Wright, Adler, Thomas, & Hoge, 2007; Thomas et al., 2010), few studies have focused on variables that may moderate the impact of combat for returning soldiers. Here, we review posttraumatic stress disorder (PTSD) and alcohol problems as two mental health outcomes related to combat stress and summarize the literature on the role of insomnia in the development and maintenance of these outcomes. Next, we examine insomnia in relation to occupational health outcomes to establish the context for high-risk occupations where individuals are exposed to traumatic events and may experience post-trauma insomnia that can affect their recovery. We then highlight the main contribution of the present research which is to examine the role of insomnia in the relationship between combat exposure and symptoms of PTSD and alcohol problems.

The role of insomnia in the development and maintenance of PTSD and alcohol problems

In a review of the literature concerning sleep disturbance and PTSD, Harvey, Jones, and Schmidt (2003) concluded that few studies have assessed the course of sleep following a traumatic event to identify patterns that may relate to the development and maintenance of PTSD. For example, there is some evidence that pre-trauma sleep disturbance is an early indicator for those who develop PTSD. Mellman, David, Kulick-Bell, Hebding, and Nolan (1995) found survivors who reported more sleep disturbance prior to Hurricane Andrew scored higher on measures of PTSD following the hurricane. In addition, several studies found that sleep disturbance reported by victims immediately following a traumatic event was associated with the later development of PTSD. For example, Koren, Arnon, Lavie, and Klein (2002), in a study of survivors of motor vehicle accidents, found sleep disturbance within 1 month post-trauma was a significant predictor of PTSD diagnosed at 12 months post-trauma. Sleep patterns reported by survivors with and without PTSD differed in severity immediately following the trauma, widened in their differences over the next 3 months and stabilized at 12 months post-trauma.

Correspondingly, Bryant and Harvey (1998) assessed survivors of motor vehicle accidents immediately following the accident and identified arousal symptoms such as insomnia, irritability and restlessness for those who developed PTSD six months later. A potential explanation for the relationship between sleep disturbance and PTSD is proposed in research conducted by Mellman, Bustamante, Fins, Pigeon, and Nolan (2002) who found PTSD symptoms assessed in survivors admitted to a trauma centre were associated with a more fragmented pattern of rapid eye movement (REM) sleep within a month of the trauma. The authors suggested the adaptive importance of REM sleep post-trauma may depend on its endurance without disruption and hypothesized sleep as a regulator of arousal that influences the processing of traumatic memories. Thus, sleep patterns that occur in the first 1 to 2 months following trauma may be important determinants of the progression of PTSD symptoms.

A limitation of many studies, however, is a need for pre-trauma baseline assessment to determine whether insomnia is a risk factor for or an early indicator of PTSD. Thus, the causal relationship between sleep and PTSD is unclear given the lack of prospective and longitudinal studies required to disentangle the temporal pattern (Babson & Feldner, 2010). Findings from the literature indicating that exposure to traumatic events may interfere with sleep; that PTSD is related to the development of insomnia; and that insomnia may interfere with recovery from PTSD symptoms all suggest a complex, reciprocal relationship between sleep and PTSD (Spoormaker & Montgomery, 2008).

Correspondingly, a reciprocal relationship between alcohol use and insomnia severity has been proposed in the literature (Blumenthal & Fine, 1996; National Institute on Alcohol Abuse and Alcoholism [NIAAA], 1998; Vitiello, 1997) where sleep problems may lead to alcohol consumption for self-medication, which in turn further disrupts sleep and results in insomnia, leading to increasing alcohol problems. There is evidence that sleep disturbance is exacerbated by alcohol problems and impairs daytime performance (Roth & Ancoli-Israel, 1999), contributes to memory dysfunction (Roehrs & Roth, 1995) and increases risk for depression and alcohol-use disorders (Gillin, 1998; Weissman, Greenwald, Nino-Murcia, & Dement, 1997). Again, however, the lack of longitudinal assessment and baseline measures precludes establishing a temporal sequence for insomnia and alcohol problems.

Thus, studies indicate that insomnia plays a role in the development and maintenance of PTSD and alcohol problems, and the present study addresses the question of insomnia severity affecting the relationship between stressors and these outcomes. The study includes soldiers participating in a combat deployment, an occupational setting at high risk for exposure to traumatic events. As such, literature related to the role of insomnia in occupational health outcomes and in high-risk occupations is summarized to provide additional context for the study.

The role of insomnia in occupational health

Within the field of occupational health, sleep problems have been conceptualized as a predictor of employee outcomes, an outcome of work stress and a mediator of the stressor–strain relationship (where stressors are demands in the work environment and strains are physiological, psychological and behaviour outcomes resulting from exposure to stressors; see Cooper, Dewe, & O'Driscoll, 2001). For example, sleep disturbance predicted feeling tense and distressed the next day at work (Sonnentag, Binnewies, & Mojza, 2008); was related to hostility, fatigue and high levels of job dissatisfaction (Scott & Judge, 2006); and a strong predictor of employee absences because of illness (Philip, Taillard, Niedhammer, Guilleminault, & Bioulac, 2001; see also Doi, Minowa, & Tango, 2003). In addition, insomnia was prospectively related to occupational outcomes in studies of military personnel (Gregg, Banderet, Reynolds, Creedon, & Rice, 2002; Johnson & Spinweber, 1983). For example, naval school students with insomnia were less likely to be promoted, more likely to leave the Navy and more likely to be hospitalized during their careers than good sleepers (Johnson & Spinweber, 1983), and insomnia assessed in soldiers predicted injuries and performance (Gregg et al., 2002). Insomnia has been identified as a consequence of work-related stress (Linton, 2004); associated with work overload, role

conflict, job autonomy, and performing repetitive tasks (Knudson, Ducharme, & Roman, 2007); and a moderator in the relationship between stress and depression in soldiers (Dolan et al., 2005).

While sleep resources are important for coping with routine occupational stressors, such resources may be essential in occupations at risk for exposure to traumatic events, such as service members deployed to combat (e.g. King, Vogt, & King, 2004). Hobfoll's (2002) conservation of resources theory provides a conceptual framework for understanding how insomnia may affect the relationship between combat exposure and psychological outcomes. In Hobfoll's theory, sleep is a biological resource necessary for coping with demands facing an individual, and problems sleeping represent a resource loss. If efforts made to replenish these losses fail, then a 'spiral of losses' can result in burnout and other psychological problems (Westman, Hobfoll, Chen, Davidson, & Laski, 2005). Using this framework, insomnia is expected to affect the relationship between combat exposure and mental health outcomes since soldiers are deprived of a critical resource necessary for processing the experiences of combat trauma.

In this study, we examined insomnia as a moderator of the relationship between combat exposure and PTSD symptoms, and between combat exposure and alcohol problems, such that combat exposure was expected to be more strongly related to mental health symptoms for soldiers who reported higher insomnia severity. We controlled for pre-deployment levels of these psychological outcomes to ensure the results were not a function of PTSD and alcohol problems soldiers may have had prior to deployment.

Method

Participants and procedure

Participants were soldiers from a combat arms battalion who completed the first mental health assessment prior to being deployed to Iraq for 12 months in 2004. The initial sample at pre-deployment was 739, and 522 of these soldiers completed the post-deployment mental health assessment 3 months after returning from Iraq in 2005. These mental health assessments were conducted as part of the US Army's psychological screening research programme (see Wright et al., 2007). Soldiers' participation in the research was voluntary and written informed consent was obtained after the procedures had been fully explained. The study was conducted under a human use protocol approved by the Institutional Review Board of the Walter Reed Army Institute of Research.

The pre-deployment sample was 98% male and 2% female. The average age of the sample was 26 years [standard deviation (SD) = 5.83]. The sample consisted of 56% Junior Enlisted (Private to Specialist), 33% Non-Commissioned Officers (Sergeant to Sergeant Major), and 11% Officers (Lieutenant to Major and Warrant Officers). In terms of ethnicity, the sample was 66% White, 16% African-American, 12% Hispanic-American, 2% Asian-American and 4% 'other'. Finally, 51% of the sample was married.

Measures: pre-deployment assessment

PTSD symptoms

PTSD symptoms were assessed using the PTSD checklist (PCL; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996; Weathers, Litz, Herman, Huska, & Keane, 1993). This well-validated measure includes 17 items that correspond to the diagnostic criteria for PTSD in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association [APA], 2000). The items are responded to on a five-point Likert scale (from 'Not at all' to 'Extremely'). Participants received a total PTSD symptom score based on the summing of their responses over 16 items. The item referring to sleep was not included in the total score to prevent artificially inflating observed relationship between insomnia severity and PTSD symptoms at post-deployment controlling for pre-deployment PTSD symptoms. Cronbach's alpha for the PCL was 0.94 in the present study.

Alcohol problems

Alcohol problems were assessed with the 10-item Alcohol Use Disorders Identification Test (AUDIT: Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). All items were re-coded onto a four-point scale, and responses across the 10 items were summed. Cronbach's alpha for the AUDIT was 0.81 in the present study.

Measures: post-deployment assessment

Insomnia severity

A standard measure was used for the post-deployment assessment of insomnia—the seven-item Insomnia Severity Index developed by Morin (1993). There is evidence indicating that the measure is reliable, valid and sensitive to interventions designed to improve sleep (Morin & Espie, 2003; Ouellet, Beaulieu-Bonneau, & Morin, 2006). Previous research also has demonstrated the validity of this scale with sleep diary assessments of insomnia symptoms (Bastien, Vallieres, & Morin, 2001). Participants indicated the severity of insomnia during the past 2 weeks, such as 'difficulty falling asleep', 'difficulty staying asleep', and 'problem waking up too early' on a five-point scale anchored by 'none' and 'very severe'. They also rated their satisfaction with their sleep, how worried/distressed they were about their sleep pattern and the extent to which the sleep pattern interfered with daily functioning. Cronbach's alpha for the seven-item scale at post-deployment was 0.90.

PTSD symptoms

PTSD symptoms were assessed with the same measure administered pre-deployment. Participants received a

total PTSD symptom score based on the summing of their responses over 16 items. Again, the item referring to sleep was not included in the total score. Cronbach's alpha for the PCL at post-deployment was 0.93.

Alcohol problems

Alcohol problems were assessed using a five-item scale. The post-deployment alcohol measure was modified from the ten-item AUDIT (AUDIT: Babor et al., 2001) used at pre-deployment because of the need for a shortened alcohol screen for the psychological screening validation studies conducted after soldiers returned from Iraq (see Wright et al., 2007). Three of the items included in the modified measure were from the AUDIT and were selected based on item analyses showing they were the strongest predictors of the overall scale (Ployhart, 2005). The other two items consisted of the two item conjoint screen (TICS; Brown, Leonard, Saunders, & Papasouliotis, 2001) developed and validated in primary care samples by Brown et al. (2001) and used in psychological screening research with military personnel (Wright et al., 2007). The TICS was included for comparison with findings from large-scale epidemiological studies being conducted with military personnel returning from Iraq and Afghanistan (Hoge et al., 2004). Participants responded 'Yes' or 'No' to the following questions: 'Did you use alcohol more than you meant to?' and 'Have you felt you wanted or needed to cut down on your drinking?' Responses were summed across the five items for a total score. Internal consistency as assessed by Cronbach's alpha for the alcohol problem measure at post-deployment was 0.72, an acceptable value given the dichotomous response format.

Combat exposure

Soldiers completed a 44-item measure of combat that was a modification of the instrument used by Hoge et al. (2004). Sample items included 'Being attacked or ambushed', and 'Handling or recovering human remains'. Participants responded to the items on a five-point scale ranging from 'Did Not Experience', to 'Experienced it with Extreme Impact'. The combat exposure construct represented the sum of the 44 items with a possible range from 44 to 176.

Results

Correlations among the measured variables

The means, SDs, and correlations among the measured variables are provided in Table I. Post-deployment insomnia severity was related to post-deployment PTSD symptoms and alcohol problems. Combat exposure was related to post-deployment PTSD symptoms and insomnia severity, as well as alcohol problems. It is worth noting that the overall levels on the outcomes were similar at pre-deployment and post-deployment. In addition, the means we obtained for PTSD symptoms are comparable with the means in other combat veteran samples (Bliese et al., 2008). As mentioned above, the alcohol problems measure we used was a modified version of that used in prior research, and therefore is not directly comparable. We are not aware of prior research using the insomnia severity measure with combat veterans.

Insomnia severity as a moderator of combat–outcome relationships

Two moderated multiple regressions were conducted to examine whether post-deployment insomnia severity interacted with combat exposure to predict post-deployment outcomes after controlling for the appropriate pre-deployment outcome. The two predictors involved in the interaction (post-deployment insomnia severity and combat exposure) were mean-centred, as recommended by Cohen, Cohen, West, and Aiken (2003). An interaction term was then created by multiplying the two predictor variables together. The significance of this interaction term was used to test whether insomnia severity was a moderator of the combat exposure–outcome relationship. The first regression involved the outcome variable of post-deployment PTSD symptoms, and the results for this regression are presented in the top half of Table II. As seen in the table, post-deployment insomnia severity interacted with combat

Table I. Correlations among the measured variables

	Mean	SD	1	2	3	4	5	6
1. PTSD (pre)	21.82	9.30	1.00	—	—	—	—	—
2. Alcohol (pre)	6.73	5.53	0.40*	1.00	—	—	—	—
3. Combat exposure (post)	76.58	24.30	0.08	0.05	1.00	—	—	—
4. Insomnia (post)	1.68	0.71	0.30*	0.21*	0.30*	1.00	—	—
5. PTSD (post)	20.61	7.78	0.36*	0.16*	0.48*	0.65*	1.00	—
6. Alcohol (post)	5.62	1.12	0.29*	0.41*	0.19*	0.37*	0.39*	1.00

Note: N for pre-deployment correlations = 739; *N*'s for post-deployment correlations ranges from 705 to 722; *N* for pre-post correlations = 520.
* Correlation is significant at the $p < 0.01$ level (two-tailed).
PTSD: post-traumatic stress disorder.

Table II. Moderated multiple regressions of insomnia severity at post-deployment and combat exposure at post-deployment as predictors of PTSD and alcohol problems

Predictors	Unstand. B	SE	DF	*t*-value	*p*-value
Outcome variable: PTSD at post-deployment					
Intercept	17.359	0.588	515	29.532	0.000
PTSD (pre)	0.122	0.025	515	4.847	0.000
Insomnia severity (post)	4.631	0.338	515	13.706	0.000
Combat exposure (post)	0.091	0.010	515	9.294	0.000
Insomnia severity * combat	0.098	0.012	515	8.307	0.000
Outcome variable: alcohol problems at post-deployment					
Intercept	5.103	0.064	515	79.164	0.000
Alcohol (pre)	0.068	0.007	515	9.137	0.000
Insomnia severity (post)	0.383	0.060	515	6.352	0.000
Combat exposure (post)	0.005	0.002	515	3.015	0.003
Insomnia severity * combat	0.006	0.002	515	2.690	0.007

Note: $N = 519$ for both the PTSD and alcohol problems outcome measures. PTSD (pre) = PTSD symptoms prior to deploying; Insomnia severity (post) = insomnia severity post-deployment; combat exposure (post) = reports of exposure to combat post-deployment; alcohol (pre) = alcohol problems prior to deploying.
PTSD: posttraumatic stress disorder; Unstand B: unstandardized beta coefficient; SE: standard error; DF: degrees of freedom.

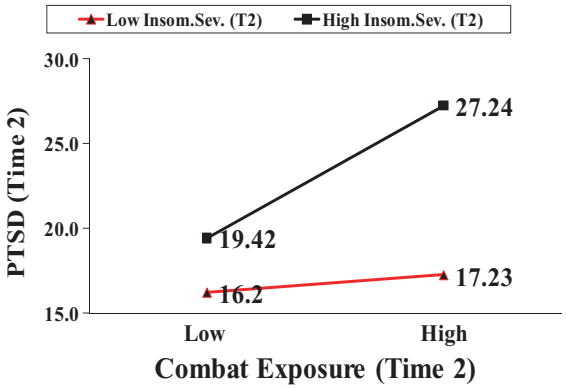

Figure 1 Insomnia severity (post) and combat exposure (post) as predictors of posttraumatic stress disorder (PTSD)

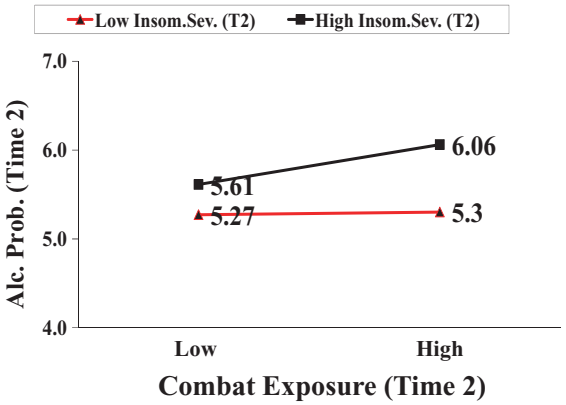

Figure 2 Insomnia severity (post) and combat exposure (post) as predictors of alcohol problems

exposure to predict post-deployment PTSD symptoms even after controlling for pre-deployment PTSD symptoms. The main effects (including pre-deployment PTSD symptoms) accounted for 53% of the variance and the interaction accounted for 6% of the variance in the outcome measure. The interaction is depicted in Figure 1 (with high and low values on the predictors corresponding to values ±1 SD from the mean; see Cohen et al., 2003), and provides support for insomnia severity as a moderator of the combat exposure-PTSD relationship. There was a slight positive relationship between combat exposure and PTSD symptoms for soldiers reporting relatively low levels of insomnia, but there was a strong relationship for soldiers reporting higher levels of insomnia. Viewed differently, the results indicate that post-deployment insomnia was a significant predictor of PTSD symptoms primarily for soldiers reporting high levels of combat. In fact, simple slope tests revealed that combat exposure was not a predictor of PTSD symptoms for soldiers reporting low levels of insomnia, $Z = 0.005$, not significant (ns), but was a strong predictor for soldiers reporting high levels of insomnia, $Z = 13.42$, $p < 0.01$.

The second regression involved the outcome variable of post-deployment alcohol problems. As seen in Table II, post-deployment insomnia severity interacted with combat exposure to predict post-deployment alcohol problems even after controlling for pre-deployment alcohol problems. The main effects (including pre-deployment alcohol problems) accounted for 29% of the variance and the interaction accounted for an additional 1% of the variance in the outcome measure. This interaction is depicted in Figure 2, and reveals the same pattern as seen for the other interaction. Combat exposure was related to alcohol problems for soldiers reporting high levels of post-deployment insomnia severity,

and insomnia severity was related to post-deployment alcohol problems primarily for soldiers exposed to high levels of combat. Again, simple slope tests revealed that combat exposure was not a predictor of alcohol problems for soldiers reporting low levels of insomnia, $Z = 0.288$, ns, but was a strong predictor for soldiers reporting high levels of insomnia, $Z = 4.50$, $p < 0.01$.

Controlling for pre-deployment insomnia severity when examining post-deployment insomnia severity as a moderator of the combat exposure–outcome relationships

In addition to controlling for pre-deployment levels of the mental health outcomes, we conducted analyses controlling for pre-deployment insomnia severity[1]. Although we did not have a standardized measure of insomnia severity at pre-deployment, there were three items assessing insomnia within the other standardized measures [one item from the Zung Self-rating Depression Scale (Zung, 1965), 'I have trouble sleeping at night'; one item from the PCL described earlier, 'Trouble falling or staying asleep'; and one item from the Patient Health Questionnaire (Spitzer, Kroenke, Williams, & the Patient Health Questionnaire Primary Care Study Group, 1999), 'Trouble falling or staying asleep or sleeping too much']. The internal consistency for the three-item scale was 0.89.

Although it is not possible to determine if insomnia worsened from pre- to post-deployment given the lack of comparability in the insomnia measures, we were able to investigate whether insomnia severity at post-deployment interacted with combat exposure to predict PTSD symptoms and alcohol problems after controlling for pre-deployment levels of insomnia (in addition to pre-deployment levels of the mental health outcomes). The results indicated that the interaction between insomnia severity at post-deployment and combat exposure was still a strong predictor of PTSD symptoms, $t(514) = 8.00$, $p < 0.01$, and alcohol problems, $t(514) = 2.76$, $p < 0.05$, after controlling for pre-deployment insomnia severity. Furthermore, the percentage of variance accounted for in post-deployment PTSD symptoms and alcohol problems was comparable (5% and 1%, respectively).

Discussion

The results provide support for insomnia as a moderator of the relationship between combat exposure and post-deployment psychological problems reported by soldiers, after controlling for pre-deployment levels of the outcomes and insomnia severity. To our knowledge, the present study is the first to examine this relationship and results suggest that insomnia severity may be important to consider when understanding how combat exposure is related to mental health outcomes for service members.

Given the lack of adequate baseline assessment of previous combat exposure, findings from the present study cannot address the temporal sequence of insomnia, combat exposure and mental health outcomes. However, the relationship between variables suggests that combat exposure and insomnia severity combine to explain a significant proportion of the variance in mental health symptoms. Consistent with Mellman et al. (2002), one explanation for the findings is that insomnia affects the relationship between combat experiences and mental health outcomes, since the cognitive processing of combat trauma and subsequent recovery from the experience may be affected. In addition, observations that insomnia increases fatigue, confusion and anxiety are further factors that may interfere with processing and recovery from traumatic exposures and contribute to the development of PTSD symptoms (Harvey et al., 2003). On the other hand, Spoormaker and Montgomery (2008) concluded that trauma-induced insomnia may be a risk factor for the development of PTSD, and that poor sleep quality *following* trauma can lead to impaired coping, poor concentration, and more frequent and intense negative emotions such as anger, sadness and anxiety. Their review is consistent with research on sleep disturbance assessed post-trauma, emphasizing a more central role for insomnia in the development of PTSD (Bryant & Harvey, 1998; Koren et al., 2002). However, determining whether pre-trauma insomnia is a risk factor magnifying the intensity of post-trauma outcomes, or whether insomnia is trauma-induced and affects subsequent recovery requires adequate prospective baseline assessment.

Interestingly, in one of the few prospective studies that examined stressful life events and sleep, Morin, Rodrigue, and Ivers (2003) found that those with insomnia rated daily minor stressors, as well as major stressful life events, as more stressful than did good sleepers. The authors concluded that individuals with insomnia who are exposed to traumatic events may experience these events as subjectively more difficult, use less effective problem-solving techniques, have difficulty exercising good judgment and use social support less effectively (King et al., 2004). Each of these factors may play a role in the potential moderating influence of insomnia on the relationship between traumatic exposure and mental health outcomes and should be considered in future research.

Correspondingly, in a recent review of the role of sleep in health outcomes, Hagger (2010) discussed the

[1]We thank anonymous reviewers for recommending the creation of the pre-deployment insomnia severity measure and for examining post-deployment insomnia severity as a moderator of the combat exposure-mental health outcome relationships after controlling for this measure.

importance of incorporating sleep when examining stress and health and described research on sleep as it assists in self-regulatory capacity that can affect recovery from stress. Such studies supporting the concept of sleep as a technique for resource replenishment are elaborated in the work of Barber, Munz, Bagsby, and Powell (2010a; 2010b), who emphasized the role of sleep consistency, in addition to sleep sufficiency, in stress management and subsequent health outcomes. In addition, Anderson (2010) and Wright (2010) both suggested these sleep variables may, in fact, combine to increase the effects of stress, and research supporting this conclusion (Benham, 2010) noted the value of distinguishing between sleep duration and quality in future studies and incorporating such sleep measures in stress reduction strategies.

Limitations

A limitation of the present research was not having validated measures of insomnia severity and prior combat exposure as part of the baseline assessment for the sample of combat veterans prior to deployment. We were able to develop an ad hoc measure of insomnia severity at pre-deployment, and the results revealed that insomnia severity assessed post-deployment continued to interact with combat exposure at post-deployment to predict the mental health outcomes at post-deployment. This provides some confidence that the levels of insomnia measured at post-assessment were present before combat exposure. However, it would be useful to replicate these results with a validated measure of insomnia at pre-deployment.

An additional concern in the present study involves the possible confound created by measuring PTSD symptoms when one of the symptoms of PTSD is difficulty sleeping. Although we removed the sleep item from the PCL at both pre- and post-deployment assessments, one might question whether it is appropriate to examine sleep as a moderator of a psychological problem where sleep problems are assessed as a symptom. We believe that this analysis is appropriate for two primary reasons. Firstly, sleep problems are mentioned in only 1 of 17 items used in the PCL to assess PTSD, mirrored by DSM IV-TR diagnostic criteria for PTSD (DSM-IV-TR; APA, 2000) where one sleep item out of five possible symptoms is required in criterion D (symptoms of increased arousal). This suggests that sleep problems are a correlate of arousal rather than a defining feature of the PTSD diagnosis itself. In addition, there is substantial evidence that insomnia occurs in the absence of other psychological disorders, thus strengthening the case that insomnia is an important clinical entity in its own right versus only a symptom of an underlying psychological disorder (Harvey, 2001; Spoormaker & Montgomery, 2008).

Secondly, when conducting the multiple regressions, we followed the established procedure of first including the main effects of combat exposure and insomnia severity prior to assessing the interaction between these variables as a predictor of PTSD symptoms. The effects of insomnia seen in the present research emerged after controlling for the main effect of insomnia severity as a predictor of PTSD. Therefore, the variation associated with the overlap between the sleep measures and PTSD was removed on the first step of the equation.

Another possible concern may be that insomnia is simply a proxy for psychological problems, and therefore the results indicate that individuals with psychological problems are less able to cope with the demands of combat. However, one argument against such an interpretation of the results is that we demonstrated the effects of insomnia severity on the relationship between combat exposure and the outcome measures after controlling for pre-deployment levels of the outcome in question. Therefore, the results are not a function of soldiers' baseline level of psychological functioning on the measures of PTSD symptoms and alcohol problems.

Future directions

The results of the study indicate the important role of sleep in soldiers' adjustment to the demands of combat. The presumed theoretical process is that insomnia deprives individuals of a critical resource required for effective functioning in and recovery from the experiences and demands of combat. Future research could investigate risk factors associated with insomnia and how this in turn affects the development of other symptoms and disorders post-trauma. In addition, the role of insomnia severity in predicting other outcomes after exposure to occupationally related traumatic events, to include behaviours influenced by judgment such as aggression, ethical decision-making during combat and risk-taking, should be examined.

There is also the need for research assessing insomnia severity as a moderator of the stressor–strain relationship, both within the military and in other occupations where sleep may be compromised through shift work schedules or involvement in continuous operations. Correspondingly, a more in-depth assessment of insomnia severity should be included in future research with those involved in high-risk occupations. For studies assessing deployment effects on military personnel, standardized measures of insomnia should be administered throughout the deployment cycle.

Showing that pre-deployment insomnia severity exacerbates the post-deployment effects of combat exposure would buttress the creation of interventions designed to reduce insomnia before, during and following deployment. For example, classes on sleep hygiene and education about the effects of alcohol on insomnia, how insomnia severity may be associated with combat-related stress reactions and affect coping under high stress conditions, could all be addressed to alert service members to the signs and symptoms of adjustment problems and when they should seek help. Finally,

research should focus on identifying why some individuals are more prone to insomnia in the first place. Whether it is difficulty in reducing physiological arousal, difficulty in reducing cognitive rumination or a combination of both, intervening before individuals are placed at risk may be a key component in managing the impact of insomnia on health outcomes following exposure to traumatic events.

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