



# Indirect associations of combat exposure with post-deployment physical symptoms in U.S. soldiers: Roles of post-traumatic stress disorder, depression and insomnia<sup>☆</sup>



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## ABSTRACT

**Objective:** To characterize the indirect associations of combat exposure with post-deployment physical symptoms through shared associations with post-traumatic stress disorder (PTSD), depression and insomnia symptoms.

**Methods:** Surveys were administered to a sample of U.S. soldiers (N = 587) three months after a 15-month deployment to Iraq. A multiple indirect effects model was used to characterize direct and indirect associations between combat exposure and physical symptoms.

**Results:** Despite a zero-order correlation between combat exposure and physical symptoms, the multiple indirect effects analysis did not provide evidence of a direct association between these variables. Evidence for a significant indirect association of combat exposure and physical symptoms was observed through PTSD, depression, and insomnia symptoms. In fact, 92% of the total effect of combat exposure on physical symptoms scores was indirect. These findings were evident even after adjusting for the physical injury and relevant demographics.

**Conclusion:** This is the first empirical study to suggest that PTSD, depression and insomnia collectively and independently contribute to the association between combat exposure and post-deployment physical symptoms. Limitations, future research directions, and potential policy implications are discussed.

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## Introduction

Post-deployment physical symptoms are commonly reported by war veterans [1–4]. The prevalence of physical symptoms following combat deployment was intensively studied in the context of reports of ‘Gulf War Syndrome.’ Although no empirical confirmation of a specific syndrome has been identified, studies have consistently revealed associations between Gulf War deployment and physical symptoms spanning multiple health domains. Studies of the most recent conflicts in Iraq and Afghanistan also provide evidence of high rates of mental and physical health problems, with rates of generalized physical health problems considerably higher in service members who have deployed compared with those who have not [1,4].

Determining mechanisms by which combat deployment contributes to physical symptoms (independent of physical injury) has proven challenging. The most recent wars have focused attention primarily on

concussion/mild traumatic brain injury (mTBI), to which many post-deployment physical symptoms have been attributed. Most studies have failed to support this association, and instead suggest that PTSD and depression are more robust correlates of persistent physical symptoms in service members and veterans with a history of mTBI [5–7]. Although there are notable differences in the combat experiences, environmental exposures, operational tempo, and mission characteristics across wars throughout history, it is perhaps telling that each, up to and including the most recent wars in Iraq and Afghanistan, has been associated with similar generalized post-deployment health concerns [2–4,8]. These data collectively suggest that a common set of deployment-related factors contribute to post-combat generalized physical health problems. However, debate has existed after every war as to the relative contribution of physical, psychological, or environmental causes of these post-war health concerns. We hypothesize that mental health conditions are essential considerations for fully explicating the association between combat exposure and physical symptoms. Collectively, PTSD, depression and insomnia are associated with endocrine [9–11], inflammatory [12–16] and autonomic nervous system [9, 17] dysregulation, each of which could contribute to general physical health symptoms. The purpose of the present study is to elucidate the relationships among these variables with the aim of determining their role in the development of post-deployment physical symptoms — an important step toward development of optimal treatment strategies.

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Previous studies suggest that the degree of combat exposure is predictive of post-deployment physical symptomatology [2,4,18–21]. Additional research is needed to more fully characterize the nature of this association. Studies have rarely systematically examined indirect associations of combat exposure and physical symptoms through highly prevalent mental health consequences of combat deployment, and studies that have done so have typically included one mental health indicator, such as PTSD, in the analysis [21]. It is estimated that 6–13% of soldiers who have returned from Iraq or Afghanistan meet criteria for post-traumatic stress disorder (PTSD), and a high rate of major depression disorder has also been documented [22]. Both of these conditions have been strongly correlated with post-deployment physical symptoms (e.g., [3]). Therefore, we hypothesize that the association between combat exposure and physical symptoms is at least in part attributable to variance shared in common with PTSD and/or depression symptoms. Indeed, it has been hypothesized elsewhere that PTSD can account for the effect of prior combat experience on physical health outcomes [21, 23], and numerous studies have shown that PTSD accounts for greater variance in persistent post-concussive symptoms than mTBI itself (e.g., [7]). Additional research is needed to determine the unique and combined contributions of these factors to the association between combat exposure and post-deployment physical symptoms.

Sleep disturbance and insomnia are prevalent in combat theater and in garrison [24–26], and have been recognized and highlighted as one of three critical areas of focus for improved soldier health and fitness, as outlined in the Army Surgeon General's 'Soldier Performance Triad'. To date, sleep has received little consideration as a risk factor for post-deployment physical symptoms. Prior studies examining post-deployment correlates of physical health have characterized and operationally defined sleep disturbance as but one component of the physical symptom milieu [1,3,7,27]. However, there exists compelling evidence from studies of civilian populations that sleep disturbance might play an important role in the development, maintenance and exacerbation of physical health problems. Sleep disturbance can be triggered and/or exacerbated by stress, and has been linked to physical symptom complaints in a number of field and laboratory studies [28]. Sleep disturbance has also been shown to enhance sensitivity to noxious stimuli in otherwise healthy individuals [29,30], and objective polysomnography indicators of sleep disturbance are common among those with chronic pain [31,32] and other physical health problems [33–35].

In the present study, we hypothesized that PTSD, depression and insomnia symptoms would emerge as important contributory factors to the link between combat exposure and post-deployment physical symptoms. Because insomnia is a phenomenological correlate of PTSD and depression, and may even share some common biological substrates with PTSD and depression [36–38], we carefully modeled the relative, or unique, contribution of each of these factors on the combat-physical symptom link. To do so, we utilized a multiple indirect effects model [39] that allowed us to systematically evaluate the direct association of combat exposure with physical symptoms, as well as whether this association was indirect and attributable to variance shared in common with PTSD, depression, and insomnia symptoms (i.e., indirect effects). We examined these associations using an extant dataset from a large cohort of U.S. soldiers following a 15-month deployment to Iraq.

## Methods

### Participants and procedures

Participants were 587 U.S. soldiers who completed a 15-month deployment to Iraq early in support of Operation Iraqi Freedom (OIF) in 2003–2004. Data for this study were collected as part of the Land Combat Study (LCS), a large multi-year investigation of the health consequences of the Iraq and Afghanistan wars on soldiers and their families. Response rates for 2003–2007 were approximately 62% [22]. Comparison of data between responders and non-responders was not

possible because only responders were given an opportunity to provide informed consent for using their data for research purposes. However, data from LCS have been highly comparable with the larger deployed population based on post-deployment health assessments [22]. Data collections were scheduled in the units in consultation with unit leaders. All data collections occurred 3 months following return from deployment. This post-deployment assessment window corresponds with post-deployment health assessments [40]. Survey data collection procedures in the present study were consistent with those reported in other LCS publications [2,5,22]. For this study, we included questionnaires that assessed demographics, combat exposure, and PTSD, depression, insomnia, and physical symptoms. Informed consent was obtained from all study participants after receiving an in-person briefing and prior to completing the survey. Study procedures were approved by the Institutional Review Board at the Walter Reed Army Institute of Research.

### Survey instruments

*Combat exposure* was assessed using a 35-item scale used in prior studies [41–43]. Three items were not included in the analyses. One of these items assessed a positive combat experience (i.e., saved someone's life). A second was an open-ended "other" option and thus could not be standardized. A third item pertained to whether a soldier experienced a combat-related injury. This item was evaluated as a covariate (see below). Soldiers responded to each combat exposure item on a 1 (never) to 5 (ten or more times) categorical scale. To compute an overall combat exposure indicator, responses from the remaining 32 items were dichotomized as 'yes' or 'no', indicating whether a soldier had experienced an event at least once during deployment, and then summed to create a single index of combat exposure severity. This computational approach taps the breadth of combat exposure [1,41,44,45]. The combat exposure scale showed excellent internal consistency, Cronbach's  $\alpha = .93$ .

*Physical symptoms* were assessed using 12 items from the 15-item Patient Health Questionnaire (PHQ-15; [46]). Two items not included in the present analysis were difficulty falling or staying asleep and feeling tired because the item content overlap with our measure of insomnia (see below). A third item pertaining to menstrual cramps was also excluded as it applied only to females. For each symptom, soldiers indicated the extent to which they were bothered over the past month. Responses were provided on a 0 (not bothered) to 2 (bothered a lot) scale. Item responses were summed to create an overall physical symptoms score. Cronbach's  $\alpha = .84$  for the PHQ-15.

*PTSD symptoms* were assessed using the 17-item National Center for PTSD Checklist – (PCL; [47]). The PCL has been validated in civilian and military populations and possesses acceptable levels of concurrent validity with structured interview assessments of PTSD [48]. Soldiers provided responses on a 1 (not at all) to 5 (extremely) scale indicating the degree to which each symptom bothered them over the past month. The nightmare and insomnia items were not included in the computation of the PCL total score, which was a sum of responses to the remaining items, in an effort to minimize inflated covariance attributable to shared item content between PCL and our insomnia measure. For PTSD caseness, a cut-off score of 50 or greater was used [22,48,49]. Note that we included the sleep item in the caseness definition so as not to underestimate probable PTSD. Internal consistency of the PCL was excellent, Cronbach's  $\alpha = .96$ .

*Depression symptoms* were assessed using the 9-item depression subscale from the Patient Health Questionnaire (PHQ-9; [50,51]), which has excellent validation compared with structured diagnostic interviews for major depression [50]. Soldiers provided responses indicating how much each symptom bothered them over the past month on a 0 (not at all) to 3 (nearly every day) scale. The PHQ-9 item concerning insomnia/hypersomnia was omitted to minimize covariance between the PHQ-9 and our measure of insomnia. The remaining 8 items were

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