The impact of post-traumatic stress on first responders: analysis of cortisol, anxiety, depression, sleep impairment and pain

Dessa Bergen-Cico, associate professor, Department of Public Health, Syracuse University, NY; **Sandra Lane,** professor of public health and anthropology, Department of Public Health, Syracuse University, NY; **Maureen Thompson,** associate professor, Department of Public Health, Syracuse University, NY **Sophia Wozny**, Contemporary OB/GYN, Laurel, Maryland; **Melissa Zajdel**, graduate student Department of Psychology, Carnegie Mellon University; **Marley Barduhn**, clinical director for CISM, Rural Metro Medical Services; **Jennifer Noce**, clinical base supervisor flight paramedic, LifeNet of New York.

Email for correspondence: dkbergen@syr.edu

Abstract

First responders are an often ignored group facing emotional and physical stress that is similar to that of law enforcement personnel and military veterans. Fifty first responder employees were invited to participate in the study, of which 34 completed the following psychological and biological measures: 1) the PTSD Checklist—Civilian Version (PCL-C); 2) State Trait Inventory for Cognitive and Somatic Anxiety (STICSA); 3) the Center for Epidemiology Studies Depression Scale (CES-D); 4) the Pittsburgh Sleep Quality Index (PSQI); 5) Alcohol Use Disorders Identification Test (AUDIT); 6) Cornell Musculoskeletal Discomfort Questionnaire (CMDQ); 7) heart rate and blood pressure during two consecutive days; 8) body mass index (BMI); and 9) salivary cortisol measured once. Among participants, 18% (n=6) met criteria for anxiety, 47% for depression (n=16) and 33% (n=12) for PTSD. Comparison of statistical models assessing the predictive strength of physical and behavioural health measures found PTSD to be the strongest predictor for depression, anxiety, poor sleep quality, musculoskeletal pain, cortisol and BMI.

A substantial portion of first responders met criteria for PTSD and anxiety. Assessing the impact of these conditions may best be achieved through physical health measures (cortisol, BMI, heart rate) in addition to psychometric screening tools (PCL, CESD, STICSA).

Key words

●Anxiety ●Cortisol ●Depression ●First responders ●Paramedics ●Post-traumatic stress

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First responders—the emergency medical technicians (EMTs) and paramedics who respond to everyday emergencies and tragedies—may experience psychological and physical stress similar to that experienced by law enforcement personnel and military veterans. Stress is defined as an event or events in which environmental demands, internal demands, or both tax or exceed the adaptive resources of an individual or their tissue system.

Stress results in hormonal (e.g. cortisol dysregulation) changes that can directly and indirectly strain the body's tissue systems and contribute to weight gain, hypertension, sleep problems, musculoskeletal pain and poor mental health (depression, anxiety). Traumatic stress refers to the stress associated with tragedies and life-threatening events such as those often witnessed by paramedics and EMTs. The physiological problems that often accompany the type of traumatic stress first responders experience may contribute to disability and include neuroendocrine changes and high levels of depressive symptomology (Stam, 2007).

Paramedics and EMTs have a larger than average number of work-related injuries and illnesses, yet the impact of physical and psychological stressors associated with their work has been understudied (Hanson, 2007; O'Mahony et al, 2008; Merchant et al, 2009; Reichard and Jackson, 2010; Bureau of Labor Statistics, 2015). Occupational stress is considered one of the strongest factors in the development of hypertension, the significance of which is evident in the 75% prevalence rate of pre-hypertension and hypertension among first responders reported in a recent study (Kales et al, 2009; Levy-Gigi and Richter-Levin, 2014).

The relationship between workplace stress and adverse psychological and physical health among first responders is similar to other high stress professions including medical, public safety, law enforcement, and military personnel (Asmundson and Stapleton, 2008; Bureau of Labor Statistics, 2015. To date, much of the research on people in crisis-oriented professions has examined acute and chronic stress disorders among first responders of large-scale natural (e.g. hurricane) and manmade (terrorist attacks) disasters; however, less is known about psychological and physical stressors EMTs and first responders experience from the day-to-day nature of their work in communities both big and small (Stein et al, 2004; Benedek et al, 2006).

First responders may experience psychological stress from repeated exposure to traumatic accidents, shootings, drug abuse/overdose, emotionally challenging calls (e.g. paediatric cardiac arrests and emotionally disturbed people).

Not only are first responders faced with day-to-day acute stressors related to the nature of their work, but many also experience chronic stress associated with job strain, sleep deprivation, and lack of work-place support. They often work under time pressure to respond to crises with limited control over their work. The schedule of their work, which often alternates day and night assignments, can lead to sleep deprivation and fatigue.

These occupational stressors have led a growing number of authors to suggest that psychological and physical ill effects may affect the first responder population, including the development of post-traumatic stress disorder (PTSD) (Alexander and Klein, 2001; Bennett et al, 2004; Benedek et al, 2007; Guenthner, 2012; Pekevski, 2013; Rabjohn, 2013). The stress of responding to human tragedies is associated with PTSD rates among first responders, which are estimated to be between 6%–32%, a figure that researchers believe to be under-reported because first responders discourage complaints of psychological distress (Kronenber et al, 2008; Haugen et al, 2012).

PTSD is a debilitating mental health condition triggered by witnessing or experiencing a traumatic or life-threatening experience. It is associated with significant functional impairment, bodily pain and poor physical and mental health (Gillock et al, 2005; Rauch et al, 2006). Diagnostic criteria of PTSD encompass i) re-experiencing the traumatic event, ii) numbing and avoidance of stimuli and reminders associated with the event, and iii) increased arousal, hyper-arousal and startle response (McFarlane et al, 2009; Haugen et al, 2012; American Psychiatric Association, 2013). Physiological problems that accompany the type of post-traumatic stress first responders experience may contribute to disability and include neuroendocrine (hormone) changes that can result in poor sleep quality, hypertension, anxiety, depression and increased health risk behaviours such as heavy use of tobacco and alcohol (McEwen, 2000; Chida and Steptoe, 2009; McFarlane et al, 2009; Juster et al, 2010; American Psychiatric Association, 2013).

One of the primary hormonal mediators of the stress response is cortisol (a glucocorticoid), which has both protective and damaging effects on the body. In the short run, cortisol is essential for adaptation, maintenance of homeostasis (balanced body chemistry), and survival (allostasis) (Chida and Steptoe, 2009). Yet, over longer time periods, dysregulation of cortisol output exacts a

Table 1. Manifestations of types of stress

Type of stress	Key symptoms
Post-traumatic stress symptoms	• Anxiety • Depression • Increased smoking, drinking, or eating as coping mechanism • Changes in eating behaviour • Increased risk for cardiovascular disease, e.g. hypertension • Trouble sleeping and recurrent, unwanted distressing memories and dreams about traumatic events • Withdrawal, loneliness (numbing) • Physical aches and pain • Dysregulation in cortisol output • Emotional reactivity, irritability, outbursts or aggressive behaviour (hyperarousal) • Always being on guard for danger (hypervigilance) • Being easily startled or frightened (startle response) • Self-destructive behaviour, e.g. heavy drinking too, risk-taking
Work-related stress symptoms	• Anxiety • Depression • Increased smoking, drinking, or eating as coping mechanism • Changes in eating behaviour • Increased risk for cardiovascular disease, e.g. hypertension • Trouble sleeping • Withdrawal, loneliness • Physical aches and pain • Increased cortisol output

cost (allostatic load) that can accelerate disease processes. The allostatic load model suggests that multi-systemic physiological dysregulation in response to chronic stress contributes to adverse effects on both physical and psychological health (McEwen, 2000; Juster et al, 2010). There are many similarities in the symptoms and manifestations of work-related stressors and PTSD. *Table 1* illustrates the major health and behavioural symptoms associated with work-related stress and post-traumatic stress; however, there are also notable differences. Given the similarities in symptoms and crossover in symptoms, it can be difficult to determine the sources of stress in order to take corrective action.

Study aims

The primary aim of this study was to assess the impact of psychological and physical stress on emergency medical technician (EMT) and paramedic first responders by analysing the relationships among biological markers, psychological health measures, and physical health outcomes among emergency medical personnel. The study's hypothesis was that higher PTSD scores among first responders would be correlated with i) greater sleep impairment and dysfunction, ii) higher depression scores, iii) higher anxiety scores (cognitive, somatic and total anxiety scores), iv) greater musculoskeletal pain, v) higher resting heart rate, vi) higher blood pressure, and vii) significantly different awakening cortisol profiles in comparison to their peers with lower PTSD scores.

Methods

This study is a University-community collaboration between Syracuse University faculty and Rural Metro Medical Services, a nationally accredited ambulance service serving the city of Syracuse and six counties in Central New York. Seventy percent of calls are emergent in nature and nearly 40% of calls require advanced life support level care.

All EMT and paramedic first responders (n=50), working at the primary community medical response centre in a mid-sized city in New York State, were invited to participate in this study. The authors received approval to conduct this research through the human subjects institutional review board (IRB) at the university where the study was conducted; and the treatment of subjects was in accordance with established ethical guidelines of the Declaration of Helsinki. Informed consent was obtained from each participant prior to their involvement in the data collection processes.

Health measures and self-report data were collected over a period of two consecutive days to accommodate the work schedule of the participants. Resting heart rate and blood pressure were measured both days to obtain repeat measures for reliability. Day one: participants completed the PTSD Checklist—Civilian Version (PCL-C), State Trait Inventory for Cognitive and Somatic Anxiety (STICSA), and the Center for Epidemiology Studies Depression Scale (CES-D). Height and weight were also collected on the first day. Day two: participants completed the Pittsburgh Sleep Quality Index (PSQI), Alcohol Use Disorders Identification Test (AUDIT), the Cigarette Dependence Scale 5-item short version (CDS-5), and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). Salivary cortisol was collected during their waking period.

Post-traumatic stress disorder (PTSD)

The PTSD Checklist—Civilian Version (PCL-C) was used to measure post-traumatic stress syndrome. The psychometric properties of the PCL-C demonstrate strong internal consistency, test–retest reliability, convergent validity, and discriminant validity. Chronbach's alpha coefficient was .87 for the total PCL-C score and .94 for re-experiencing, .84 avoidance, and .85 hyper-arousal sub-scores (Conybeare et al, 2012).

Anxiety

Anxiety was measured using the State-Trait Inventory for Cognitive and Somatic Anxiety—Trait version (STICSA). The STICSA Trait yields three scores: i) cognitive anxiety, ii) somatic anxiety, and iii) composite (total) score. The STICSA Trait is comprised of 21 questions, which ask respondents 'how often, in general, the statement is true of you?' Respondents rate each item on a 4-point Likert scale from 1 (not at all) to 4 (very much so), with a potential score range from 21 to 84. The STICSA is designed to be a measure of anxiety with good discriminant validity for symptoms unique to anxiety (somatic facets such as physiological arousal or cognitive facets such as anxious thoughts) rather than nonspecific or depressive symptoms (Grös et al, 2007).

Depression

Depression was measured using the Center for Epidemiology Studies Depression Scale (CES-D). Internal consistency is reported at .85 (Radloff, 1977).

Measurement of sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to measure the quality and patterns of sleep. The PSQI has internal consistency and a reliability coefficient of .83 for its seven components: i) subjective sleep quality, ii) sleep latency (time it takes to fall asleep), iii) sleep duration, iv) habitual sleep efficiency, v) sleep disturbances, vi) use of sleeping medication and vii) daytime dysfunction for the previous month (Buysse et al, 1989).

Alcohol use

An adapted form of the Alcohol Use Disorders Identification Test (AUDIT) was used to assess problematic alcohol use. The AUDIT is designed to identify alcohol-related problems in the previous year. For purposes of this study we adapted the instrument to identify alcohol-related problems as they have occurred in the previous 30 days. In its standard form the AUDIT asks about alcohol use in the previous year and is a validated, reliable (alpha=.90), 10-item instrument designed to identify individuals at risk for problems because of their alcohol use over the previous year (Babor et al, 2001).

Tobacco use

Tobacco use was measured with the Cigarette Dependence Scale 5-item short version (CDS-5) (Etter et al, 2003).

Measurement of musculoskeletal discomfort

The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to measure musculoskeletal aches and pains. Internal reliability is reported to be .87 for the frequency subscale, .89 for the severity subscale and .87 for the interference subscale (Erdinc et al, 2011).

Biomarkers

Height and weight

Height and weight were measured using a calibrated medical scale. Body mass index (BMI) was calculated as the ratio of weight to height with the formula weight (kg) / (height (m))^2 (Garrow and Webster, 1985).

Cardiovascular measures: blood pressure and resting heart rate

Heart rate and blood pressure values were measured with the A and D Medical LifeSource UA-787EJ portable electronic blood pressure monitor before and after the work shift on day one and day two. This electronic blood pressure monitor has been clinically validated and gives reliable readings when used correctly. Mean systolic and diastolic measures were calculated by averaging the systolic readings, then the diastolic readings obtained before the participants' shifts on day one and day two. This process was repeated for the readings obtained at the end of their shift on each of the two days. In addition to examining the mean systolic and diastolic readings, we analysed potential differences before and after their shifts.

Cortisol

Salivary cortisol has been found to be an effective bio-measurement of the stress response in research on PTSD among police officers (Groer et al, 2010). Higher levels of depressive symptomology and chronic stress have been found to be associated with higher cortisol levels and increases in cortisol after awakening (Adam et al, 2006; Fries et al, 2009).

To explore the potential impact of stress and trauma on the first responders we measured participants' cortisol awakening response (CAR). The CAR was measured in three ways: i) the CAR formula developed by Clow et al (2004); ii) area under the curve (AUC) with respect to ground (AUC_G) which indexes the total AUC; and iii) AUC with respect to increase (AUC_I), which indexes the increase during the awakening response from the first awakening value during the 45-minute waking period.

The AUC_G and AUC_I were calculated with formulas recommended by Preussner et al (1997). The area under the curve with respect to the ground reflects total cortisol output during the day. This score allows us to calculate baseline cortisol measures and reactivity between measures, thus taking full advantage of the information provided to predict cortisol profiles while maintaining degrees of freedom. All of these measures, however, are based on the distance from zero (or ground). The measurement of AUC_I ignores the distance from zero and highlights changes over time. The formula for AUC_I is an estimate of cortisol output from the formula for AUC_G, with the exception that the measurement of cortisol output between the ground and the first salivary measure upon awakening is eliminated. The use of AUC_I best indicates responsiveness to change in diurnal cortisol output as an index of stress reactivity (Preussner et al, 1997; Fekedulegn et al, 2007).

The CAR was measured using cortisol readings obtained from salivary oral samples collected during the morning waking response phase. Cortisol was measured for one day upon waking, and then again at 30 minutes and 45 minutes after waking. Subjects used Salimetrics™ salivary using salivate swabs and collection tubes. Samples were analysed at Salimetrics™ lab in State College, PA.

Statistical approach

We examined bivariate correlations among variables within categories of behavioural and somatic measures. Multiple regression analyses were then conducted to examine the interactions between behavioural and somatic variables. Our final step in the analyses encompassed logistical regression to examine the strength of each predictive model. Because of the small sample size, bootstrapping was conducted as is recommended for smaller samples (Keselman et al, 2004). All analyses were conducted using SPSS 20.

Results

Participants

Fifty Rural Metro employees were invited to participate in the study; of those 34 (68%) completed psychological instruments and biological measures. In general, first responders who chose not to participate declined due to the time commitment required for data collection and biomarker measurement. The majority of the sample was male 69% (*n*=25) and White (86%). Fifty percent (*n*=17) of the participants had a second job. The first responders working in this agency worked one of three 12-hour shifts covering the 24-hour cycle. The largest proportion 44% (*n*=16) of participants worked the day shift (9am–9pm); 17% (*n*=6) worked a combination day/evening second shift (12pm–12am); and 33% (*n*=12) worked the overnight shift (9pm–9am). The mean number of years on the job was 6.3±5.7 (ranging from 5 months to 23 years).

Binary logistic regression found no significant relationship between age, gender, race, shift, or years on the job and PTSD (p=.09), depression (p=.23), or anxiety (p=.09). Therefore the demographic variables were not controlled for in the subsequent analyses.

Cognitive and behavioral health measures

Post-traumatic stress disorder

The mean PCL-C score for the group was 26.8±13.1. Thirty-three percent (*n*=12) of the participants met criteria for PTSD or sub-threshold PTSD. Analysis of variance was conducted between groups comparing first responders with higher PTSD scores and those with lower PTSD scores. Analysis of variance between female and male first responders found female participants had significantly higher (37.3±17.6). PCL scores compared to their male colleagues (25.1±6.5) F (1, 32)=9.1, p=.005.

PCL scores were significantly and positively correlated with depression (CESD), cognitive anxiety, somatic anxiety and composite anxiety scores (STICSA). Analysis of variance between groups found significant differences between first responders with PTSD and those without PTSD for the total STICSA score F (1, 32)=26.4, p=.001; cognitive anxiety score F (1, 32)=33.4, p=.0001); and somatic anxiety score F (1, 32)=14.6, p =.001. The PCL scores were significantly correlated ($p \leq .05$) to all of the anxiety measures and are presented in *Table 2*. This was expected due to the high degree of colinearity among the anxiety measures.

PCL scores were also significantly ($p \leq .05$) and positively correlated with poor sleep quality, delayed onset of sleep (latency), daytime dysfunction due to poor sleep and sleep duration. These findings are presented in *Table 2* and discussed in detail below.

Anxiety

The mean STICSA score for the group was 35±13; the mean cognitive anxiety score was 17±6.5 and 18±7 for somatic anxiety. This study used the STICSA composite cut-off score of 40 to screen for the possible presence of anxiety disorders among non-clinical populations as recommended by Van Dam et al (2013)

Table 2. Pearson Correlation post-traumatic stress disorder, depression, anxiety and sleep measures

	Post-traumatic stress disorders score	Depression	Cognitive anxiety	Somatic anxiety	State-trait inventory for cognitive and somatic anxiety	Sleep quality	Sleep disturbance
Post-traumatic stress disorder score	1.0	**.72***	**.86****	**.84****	**.90****	0.52	0.50
Depression	**.72***	1.0	**.76***	**.85****	**.85****	**.70***	**.78***
Cognitive anxiety	**.86****	**.76***	1.0	**.80****	**.94****	**.82****	**.74***
Somatic anxiety	**.84****	**.85****	**.80****	1.0	**.96****	0.61	0.61
State-trait inventory for cognitive and somatic anxiety	**.90****	**.85****	**.94****	**.96****	1.0	**.75***	**.71***

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*
Bold items are significant. Bootstrap results based on 1000 bootstrap samples

and the adjusted cognitive (20) and somatic (20) anxiety cut off scores according to the methodology recommended by Grös et al (2007). Eighteen percent (*n*=6) of participants met criteria for anxiety based on total STICSA score of 40 or greater; 18% had cognitive anxiety scores above 20, and 29% (*n*=10) had somatic anxiety scores above the cut off score of 20.

Total STICSA score and somatic anxiety were significantly positively correlated ($p \leq .001$) with AUC_I when calculated using both non-transformed and log-transformed cortisol measures. There were no significant correlations between cognitive anxiety scores and any of the cortisol measures. Cortisol correlates are presented in *Table 3*. There were no significant differences between groups for heart rate when comparing participants with anxiety to those without anxiety (<40 STICSA score).

Depression

A substantial portion 47% (*n*=16) met criteria for depressive symptomology based on their CESD score. There were significant differences between first responders with PTSD and those without PTSD for CESD F (1, 32)=17.4, p=.0001. The PCL scores were significantly correlated with depression, which is presented in *Table 2*.

Depression scores were not significantly correlated to any of the cortisol measures. Moreover there were no significant differences between groups for cortisol when comparing participants who were above the cut score for depression compared to those who did not screen positive. There were no significant differences between groups for heart rate.

Sleep

Analysis of variance revealed significant differences between first responders with PTSD and those without PTSD for Pittsburgh Sleep Quality F (1, 32)=6.1, p=.02. PTSD scores were significantly correlated to overall sleep quality (.53, p=.001); daytime dysfunction due to poor sleep quality (.38, (p=.03); length of time it takes to fall asleep (.44, p<.001); and sleep duration (.60, $p \leq .001$). These data are presented in *Table 2*.

There were positive correlation for depression and sleep measures; however, analysis of variance did not reveal any significant differences for any of the sleep measures between groups of participants who screened positive for depression and those who did not. See *Table 2*

Alcohol and tobacco use

The majority of the participants (76.5%) reported limited to moderate alcohol use. Tobacco use was also low with only 8% (*n*=3) of participants reporting that they were smokers. Participants' AUDIT scores were not significantly correlated to scores for PTSD, depression, or anxiety at the $p \leq .05$ level.

Table 3. Pearson Correlation post-traumatic stress disorder, depression, anxiety and cortisol

	Area under the curve increase	Area under the curve increase log transformed
Post-traumatic stress disorder check list score	**.45****	**.51****
Depression	.27	.28
Cognitive anxiety	.25	.29
Somatic anxiety	**.42***	**.43***
State-trait inventory for cognitive and somatic anxiety	**.36***	**.38***

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*
Bold items are significant. Bootstrap results based on 1 000 bootstrap samples

Physical and biological measures

As noted, the measure for anxiety encompassed measures for somatic as well as cognitive anxiety. Here we present the somatic and physiological measures

Cortisol

As is often the case in this type of cortisol analysis, there was substantial variability in the distribution of the data. To correct for non-normal data distribution the data were log transformed. To correct for the small sample size, analyses were conducted using bootstrapping methods recommended for smaller samples (Keselman et al, 2004; Adam et al, 2006). Log transformation, combined with bootstrapping methods, improves Type I error control and probability for small samples with non-normal distribution. Log transformation combined with bootstrapping methods improves Type I error control and probability for small samples with non-normal distribution.

There were significant differences between groups with and without PTSD for AUC F (1, 32)=5, p=.03 and AUC_I F (1, 32)=4.6, p=.04. However, AUC_G was not significantly different F (1, 32)=.29, p=.6. Refer to *Table 3* for details on the correlation between cortisol and PTSD, depression and anxiety measures.

PTSD score was significantly correlated to the AUC_I for cortisol as analysed by log-transformed cortisol data (r=.51, *p*≤.001). Anxiety was also significantly related to AUC_I for log-transformed data r=.38 (*p*≤.001) and non-log transformed AUC_I (r=.36, *p*=.05). Somatic anxiety was significantly correlated with AUC_I (r=.42, *p*≤.05) and log transformed AUC_I r=.43 (*p*≤.05). However, cognitive anxiety was not correlated with any cortisol readings and there were no significant correlations between any cortisol measures and depression. The multiple regression model with the coefficients for PTSD, depression and anxiety was significant for predicting AUC_I (R=.56, R^2=.31, F (4, 27)=3.1, *p*=.03).

Cardiovascular health

Thirty eight percent (*n*=13) of the total sample met the clinical definition for hypertension, defined as systolic BP≥140 mmHg and diastolic BP≥90 mmHg (Pruessner et al, 1997). Nine percent (*n*=3) met the clinical definition for tachycardia (resting HRx4≥100). However, screening positive for PTSD, depression, or anxiety was not significantly correlated to either systolic or diastolic blood pressure readings.

There were significant differences between the participants with and without PTSD for resting heart rate F (1, 32)=9.2, *p*=.005. The mean resting heart rate for the participants without PTSD was 71.8±17.8 compared to those with PTSD 88.9±10.9. PTSD was also significantly correlated with resting heart rate (r=.47; *p*=.005). There were no significant differences in resting heart rate between participants who screened positive for depression or anxiety.

Body mass index

The majority 59% (*n*=20) met criteria for being overweight or obese according to their body mass index (BMI). Among participants who met criteria for PTSD 67% (*n*=8) were overweight with BMI≥25%, and 50% (*n*=6) met obesity criteria with a BMI≥30%. Among participants who did not meet criteria for PTSD 64% (*n*=14) were overweight with BMI≥25%. However, only 18% (*n*=4) met obesity criteria with a BMI≥30%.

BMI was significantly correlated with resting heart rate (r=.36; *p*=.05); mean systolic blood pressure (r=.39; *p*=.04) and mean diastolic blood pressure (r=.45; *p*=.01). BMI was not significantly correlated with PTSD, depression, or any anxiety measures. BMI was significantly positively correlated with musculoskeletal pain, pain in the past week, degree of discomfort and pain that interfered with work. With regard to cardiovascular measures, BMI was not significantly correlated with resting heart rate; however, it was significantly correlated with diastolic (r= .386; *p*=.04) and systolic (r=.453; *p*=.012) blood pressure.

BMI was also significantly correlated with musculoskeletal pain for each of the four measures of the CMDQ: i) pain in the previous week (r=.53; *p*=.003), ii) degree of discomfort (r=.42; *p*=.02), iii) degree of interference with work (r=.42; *p*=.02), and iv) composite musculoskeletal pain score (r=.48; *p*=.007).

Musculoskeletal pain

The participants' scores for the PCL, cognitive anxiety, somatic anxiety and STICSA total were each significantly positively correlated with musculoskeletal pain for each of the four pain measures of the CMDQ. There were no significant differences in musculoskeletal pain between participants who screen positive for PTSD or depression, and participants' depression scores were not significantly correlated to any pain measures. Data on correlation between pain and psychological distress are presented in *Table 4*.

The final steps in the analyses were to conduct a series of multiple regression analyses to examine the overall strength of predictive models for behavioural health variables (PTSD, depression, anxiety, alcohol use and sleep quality) and physical measures (cortisol, heart rate, blood pressure, BMI, pain) on the dependent variables for PTSD, depression and anxiety.

Table 4. Pearson Correlation post-traumatic stress disorder, depression, anxiety and pain

	Past week pain	Degree of discomfort	Work interference	Total pain score
Post-traumatic stress disorder check list score	**.46****	.35	**.40***	**.43***
Depression	.34	.31	.25	.31
Cognitive anxiety	**.49****	**.42***	**.49****	**.49****
Somatic anxiety	**.40***	**.37***	**.40***	**.40***
State-trait inventory for cognitive and somatic anxiety	**.46****	**.41***	**.46****	**.47****

**Correlation is significant at the 0.05 level (2-tailed).*
***Correlation is significant at the 0.01 level (2-tailed).*
Bold items are significant. Bootstrap results based on 1 000 bootstrap samples

Predictive models

None of the multiple regression models assessing the predictive strength of behavioural health coefficients (AUDIT score, sleep quality, sleep disturbance, daytime dysfunction related to sleep) were significant predictors for anxiety, PTSD or depression at the p≤.05 level.

The multiple regression model assessing the predictive strength of somatic health coefficients (AUC_I, heart rate, systolic BP, diastolic BP, BMI, pain) on depression (CESD) was not significant R=.42, R^2=.17, F (8, 29)=.563, p=.79. The multiple regression model assessing the predictive strength of somatic health coefficients on PTSD (PCL score) approached significance R=.68, R^2=.47, F (8, 29)=2.3, p=.06. Further analysis of the coefficients within the model found that only cortisol AUC_I was a significant predictor variable (p=.04).

Similarly, the multiple regression model assessing the predictive strength of somatic health coefficients on anxiety score (STICSA) approached significance R=.69, R^2=.48, F (8, 28)=2.64, p=.07. Further analysis of the coefficients within the model found that only resting heart rate was significant (p=.05) among the variables. The model examining cognitive anxiety was significant R=.70, R^2=.49, F (8, 28)=2.46, p=.05. Again the only coefficient that contributed significantly to the model was resting heart rate (p=.02). The model for somatic anxiety was not significant R=.62, R^2=.39, F (8, 29)=1.7, p=.16. The three strongest predictive models are presented in *Table 5*.

Strongest predictive model

Ultimately, the analysis of the data in separate categories of behavioural health and somatic measures did not yield strong predictive models. The strongest regression model was the model which encompassed both somatic and behavioural health measures as predictors of PTSD score R=.94, R^2=.88, F (9, 28)=16.7, p≤.001. In this model the correlation coefficients included depression, anxiety (total, somatic, cognitive), musculoskeletal pain (all four measures), cortisol AUC_I and BMI. Accordingly, using the slightly more conservative adjusted R squared value for this model we can conclude that 83% of the variance in PCL scores can be predicted by the variables in this model. Furthermore, the coefficients that contributed significantly to the model were AUC_I, BMI and the degree of discomfort for musculoskeletal pain.

Table 5. Comparison of models predicting post-traumatic stress disorder, depression and anxiety

Dependent variable of predicted model	R	R Square	Adjusted R Square	F	Significance
Post-traumatic stress disorder	0.94	0.88	0.83	16.7	p≤.01
Depression	0.89	0.79	0.70	8.4	p≤.01
Anxiety	0.91	0.83	0.76	12.2	p≤.01

Discussion

At 33%, the rate of PTSD for this study sample was higher than the rate reported in research for similar non-indicated community samples of EMTs and paramedics, which has been reported as ranging from 8%–22% (Alexander and Klein, 2001; Bennett et al, 2004; Benedek et al, 2007; Guenthner, 2012; Haugen et al, 2012; Pekevski, 2013; Rabjohn, 2013). The PTSD rates of our sample were moderately higher than studies of first responders working in sites of major natural disasters (e.g. Hurricane Katrina) and man-made disasters (e.g. the 2001 attacks on the World Trade Center), which found PTSD rates among first responders to be around 32% (Haugen et al, 2012). Natural and man-made disasters, while extreme, are generally time-limited, whereas first responders working in a fast-paced urban EMS environment may experience chronically higher levels of PTSD symptoms than previous research has suggested. Moreover, this study found that PTSD was also the strongest predictor of health-related problems—stronger than depression, anxiety or job strain. Thus it is of upmost importance that the mental health of EMTs and paramedics is recognised as vital to their wellbeing and ability to function effectively. Addressing stress—particularly traumatic stress—should be recognised as a strength and a responsible protective measure against health risks.

Poor sleep quality and physical aches and pains often accompany anxiety, depression, and PTSD. Likewise, poor sleep quality can exacerbate depression. Together these factors make it difficulty to determine the temporal order of the relationship of these variables and symptoms. However, given the fact that PTSD was the strongest predictor of physical and mental health problems it is important to screen for and address PTSD among first responders.

Our findings provide further evidence that the stressors first responders face impacts their hypothalamic–pituitary–adrenal axis function, as indicated by the dysregulation in cortisol awakening response profiles among those with PTSD. There were differences in the cortisol response between depression, cognitive anxiety, and somatic anxiety. Somatic anxiety was significantly correlated with cortisol for the AUC_I measure; however, neither cognitive anxiety nor depression were significantly correlated with cortisol. The reason for the

Key points

- The impact of traumatic stress and/or post-traumatic stress disorder (PTSD) affects paramedics and emergency medical technicians (EMTs) physically as well as psychologically.
- PTSD among these first responders is associated with biomarkers that indicate neuroendocrine changes (e.g. cortisol, blood pressure) that may contribute to disability.
- Paramedics who meet PTSD criteria are more likely to have high blood pressure and dysregulated cortisol awakening response than their peers who do not meet criteria for PTSD.
- Paramedics with PTSD experience poor sleep quality, depression, musculoskeletal pain, job strain, and more anxiety than their peers without PTSD.

differences in somatic and cognitive responses to anxiety can differ among individuals and groups depending on the environmental norms and role expectations. The role of EMTs and the environment in which they work may make stress seem normative, therefore they may not experience it cognitively yet their body reacts. Calm in the face of stress is valorised in emergency medicine. Therefore simply measuring depression or perceived stress may not adequately capture the impact of chronic or traumatic stress. Physical pain and discomfort, however, were significantly correlated with somatic, cognitive and overall anxiety. It may be that it is more acceptable to acknowledge and identify physical pain and discomfort.

Limitations

This study is limited by the fact that there were only 34 first responders who agreed to participate in the study. However, the moderate number of participants represents 68% of the original pool of prospective study subjects contacted to participate in this research. Another potential limitation is the salivary cortisol data. Salivary cortisol was collected for a single day, and best practices recommend collecting salivary cortisol for two consecutive days and averaging values across two days to account for potential variations in cortisol. These factors may limit the generalisability of the data findings to all first responders. Wilkins et al (2011) have noted that further research is needed to evaluate the ability of the PTSD Checklist Civilian Version (PCL-C) to discriminate PTSD from disorders characterised by negative emotionality, such as anxiety and depression. Moreover, there is a high degree of multicollinearity between anxiety, depression, and PTSD (Grevin, 1996; Asmundson and Stapleton, 2008; Wilkins et al, 2011), which can make it difficult to interpret regression analysis. Research with larger samples and repeated measures of cortisol are needed to better understand the physiological impact of traumatic stress on first responders.

Conclusions

Based on the findings from this study we recommend assessing the impact of traumatic stress using physical health measures in addition to screening tools such as the PCL, CESD or STICSA. The impact of traumatic stress affects individuals physically as well as psychologically. Comprehensive assessment of physical measures such as musculoskeletal pain, cortisol, and resting heart rate may provide evidence of the toll the stress is taking on individuals who work as first responders. We further endorse the *Task Performance and Health Improvement Recommendations for EMS Practitioners* (American Council on Exercise, 2012) developed in conjunction with the National Association of EMTs. With EMS workers seven times more likely than other workers to miss work as a result of injury, and with half of all EMS workers suffering back pain annually, we also recommend that EMS agencies incorporate regular physical fitness testing and programming to improve the overall health of this first responder workforce.

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