Post-traumatic stress symptoms and cortisol patterns among police officers

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Abstract

Purpose – The purpose of the present study is to examine associations between post-traumatic stress disorder (PTSD) symptoms and salivary cortisol parameters.

Design/methodology/approach – PTSD symptoms and cortisol responses were measured in a random sample of 100 police officers. The impact of event scale (IES) categorized into subclinical, mild, moderate and severe levels was employed to measure PTSD symptoms. Cortisol was analyzed from saliva samples over a period of three days and included an awakening response, high protein lunch challenge, whole day (diurnal), and a dexamethasone suppression test (DST).

Findings – Officers in moderate and severe PTSD symptom categories had higher mean awakening cortisol values. A significant sample-time by PTSD interaction ($p = 0.008$) was found for awakening cortisol responses. Officers in the severe PTSD symptom category showed a blunted response to the cortisol protein meal challenge compared to those in lower PTSD categories. Diurnal cortisol levels suggested an increasing trend across subclinical to severe PTSD categories respectively ($p = 0.15$ test for trend). DST ratios were lower in moderate and severe PTSD symptom categories (6.86 and 8.03 respectively) than in the subclinical and mild categories (9.32 and 10.43 respectively).

Research limitations/implications – The sample was not representative of all police in the USA. These results suggest that associations between psychological trauma symptoms and dysregulation of cortisol patterns may exist and could possibly affect future health outcomes in police officers.

Practical implications – Exposure to trauma and disaster events emphasizes the need to further investigate the health impact of PTSD on police personnel as well as other first responder groups.

Originality/value – This article will not only be of interest to those in the police service but to the general public. The present study may serve to provide a guide for larger police population investigations on PTSD and physiological impact.

Keywords Post-traumatic stress disorders, Police, Occupational health and safety, United States of America

Paper type Research paper

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Introduction

PTSD and police work

Selye (1984) recognized police work as a stressful occupation. Police work has been described as "civilian combat", and police officers face the almost certain possibility of exposure to traumatic events in their work (Violanti and Paton, 1999). Examples of traumatic occurrences include shootings, physical assault, witnessing violence and familial abuse, handling dead bodies, and disaster scenes such as 9/11 or Hurricane Katrina in New Orleans (Paton and Smith, 1996; Paton and Violanti, 1997; Paton *et al.* (2004). Multiple exposures to such trauma increases the risk of psychological disorders such as post-traumatic stress disorder (PTSD) and depression (Stephens *et al.*, 1999). Even officers whose PTSD symptoms are in remission may experience a reactivation of symptoms from earlier job related traumas (Wilczak, 2002; Violanti, 2002).

The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) pilot study was conducted to establish a baseline for the first known population-based study designed to identify biomarkers of stress and psychosocial factors in the high stress occupation of police work (see Violanti *et al.*, 2006 for a description of the full methodology). The present paper describes findings from the BCOPS pilot study concerning the association between reported PTSD symptoms and the salivary cortisol response patterns observed: at awakening;

- after a high protein meal challenge;
- over the course of a day; and
- after taking a low dosage (0.5 mg) of dexamethasone at bedtime-a dexamethasone suppression test (DST).

Methods

Police sample

The Buffalo, New York Police Department, an urban police force of 934 officers at the time of sampling, was the selected police site. A random sample ($n = 100$) was generated in the department using a computer-generated random number table. No specific inclusion criteria were used for the study other than the participant should be a sworn police officer and willing to participate in the study. Officers with missing data ($n = 8$) were excluded from analysis. One officer had missing PTSD data, and seven had incomplete cortisol samples. A final sample of 92 officers was included for analysis. All phases, testing, and reports of the study were approved by the State University of New York at Buffalo Internal Review Board and the National Institute for Occupational Safety and Health Human Subjects Review Board. The Center for Preventive Medicine, State University of New York at Buffalo, School of Public Health and Health Professions, Buffalo, NY, served as the data collection site.

Measures

PTSD symptomatology

The impact of event scale (IES) was used to measure psychological symptoms of PTSD (Horowitz *et al.* (1979)). The IES was categorized based on a previously established formulation (Beaton *et al.*, 1999; Corneil *et al.*, 1999). Categorization was based on the mean IES score of a norm group of diagnosed PTSD patients admitted for treatment (M = 35.3; SD = 17.2) (Horowitz *et al.* (1979)). A 0.50 standard deviation from the mean

defined trauma stress levels, since that variation limit best distinguished those with mild and those with moderate or severe reported trauma stress symptoms. Consistent with other studies, the following levels of PTSD symptomatology were employed: 0-8 (subclinical); 9-25 (mild); 26-43 (moderate); and > 44 (severe). The prevalence of elevated PTSD symptoms was defined using both the moderate and severe categories (IES score ≥ 26), consistent with several other studies (Chang *et al.*, 2003; Corneil *et al.*, 1999; Langeveld *et al.*, 2004; Williams *et al.*, 2002).

Salivary cortisol

Cortisol has long been considered a biomarker for both acute and chronic stress (McEwen, 2004). Although cortisol can feasibly be measured in blood, urine and saliva, its measurement in saliva has come to be preferred because the cortisol present is unbound thus providing the level of biologically active hormone and the small amounts present in saliva can be easily detected and quantified by immunoassay. Officers were provided with Salivettes (Sarstedt, USA), a commercially available collection device consisting of a dental roll and a centrifuge tube, for the collection of saliva samples; at the designated collection time the dental roll is removed from the centrifuge tube and placed in the mouth for approximately two minutes allowing for saturation of the roll. In the lab, the tube is centrifuged to provide a non-viscous saliva sample for assay; centrifuged samples are maintained at − 20°C until assayed for cortisol by a commercially available chemiluminescence immunoassay (IBL, Hamburg, Germany) at the Technical University of Dresden (Dressendorfer *et al.*, 1992).

Cortisol was measured in saliva under the following conditions or challenges for the purposes of the present study:

- A high protein meal cortisol challenge was performed at the clinic site, which involved collection of a baseline saliva sample immediately followed by the ingestion of a high protein shake consisting of commercially available protein and carbohydrate powder mixed in water to provide 55 grams of protein to serve as a convenient substitute for a high protein meal; four additional samples were collected at 15 minute intervals beginning 15 minutes after the shake was finished (Rosmond and Bjorntorp, 1998, 2000);
- Officers were provided with eight additional Salivettes and a 0.5 mg dexamethasone tablet for off-clinic site testing and collection of saliva over the next two days to determine cortisol levels at awakening, over the course of the day (i.e. diurnal), and following the dexamethasone tablet at bedtime for the DST (Table I).

Statistical analysis

The cortisol data distributions, between subjects at each time point in the study, were examined and found to be approximately lognormal. Because of this the data were log-transformed to normalize the distribution prior to the application of parametric statistical methods (e.g. ANCOVA). Small numbers of apparent outliers in salivary cortisol data may also exert undue influence on analytical results (Neylan *et al.*, 2005). In the present study a few cortisol measurements fell clearly outside the expected range of the assay. We applied several approaches to deal with extreme outliers including the following:

Sample no.	Day	Approximate time	Sample characteristics
1	1	11:10 am	Baseline (prior to protein lunchtime challenge)
2	1	11:20–12:30	15 minutes after lunchtime challenge
3	1	11:20–12:30	30 minutes after lunchtime challenge
4	1	11:20–12:30	45 minutes after lunchtime challenge
5	1	11:20–12:30	60 minutes after lunchtime challenge
6	2	Awakening	First Awakening sample
7	2	Awakening	15 minutes after awakening
8	2	Awakening	30 minutes after awakening
9	2	Awakening	45 minutes after awakening
10	2	Lunchtime	Immediately before eating midday meal
11	2	Dinnertime	Immediately before eating evening meal
12	2	Bedtime	Before bedtime and before taking dexamethasone tablet
13	3	Awakening	Post dexamethasone awakening sample

Table I.
Timing of salivary cortisol sampling, BCOPS pilot study

- repeated assays to confirm outlier status;
- used high performance liquid chromatography (HPLC) to examine samples from participants with repeated outlying cortisol values (e.g. greater than 200 nmol/L) to confirm these high values were not due to authentic cortisol (such examination resulted in the elimination of data from three participants); and
- consistent with previous studies of this type (Neylan *et al.*, 2005) converted any remaining cortisol value greater than 2.3 standard deviations above the mean to a missing case.

In order to perform this last step we computed the mean plus 2.3 standard deviations for log cortisol for all time points during the diurnal cortisol sampling. We then back-transformed these to the concentration scale and used the largest value (152 nmol/L) as our cut point for setting individual cortisol values to missing. This led to a total of seven cortisol values (among four participants) being set to missing.

ANCOVA was used to analyze associations between cortisol levels and PTSD symptom categories. Unadjusted and adjusted means and 95 percent confidence intervals were calculated using log scale data and then back-transformed into concentration scale for convenience of results interpretation. Waking and high protein meal data were analyzed using mixed models to account for the correlation between repeated measurements within individual participants (SAS Proc Mixed (SAS/STAT Users Guide, Version 8, Cary, NC: SAS Institute Inc., 1999).

Preliminary analyses determined the optimal covariance structure for inclusion into mixed models to be compound symmetric within PTSD groups, allowing covariance and variance parameters to vary between PTSD groups. A two-way PTSD group by cortisol sample-time interaction model was calculated for both the waking and lunch responses in order to determine whether or not the responses were parallel between PTSD groups. Diurnal AUC was calculated using the trapezoidal rule for numerical integration (Pruessner *et al.*, 2003). Other variables were assessed with simple one-way ANCOVAs for differences in PTSD group means.

In addition to one-way tests for equality among means across the PTSD groups we also calculated a one degree of freedom test for linear trend across the four PTSD

groups using a linear contrast. This approach has more power than the statistical test for equality among the group means and tests the null hypothesis of a linear trend across the groups. This test was reported where it was reasonable to assume the possibility of a linear trend in the data. Regression analyses using the IES score as a continuous predictor for the various cortisol parameters (results not shown) led to *p*-values of similar magnitude to those obtained using the linear contrast approach.

The DST was reported as the ratio of the first waking cortisol level, without dexamethasone, to the post dexamethasone first waking value because the ratio corresponds to a difference when data are log transformed, allowing for valid statistical comparisons and straightforward interpretation of suppression as a fold change in cortisol levels after administration of dexamethasone. In other words, the ratio in concentration scale is analogous to a pre-post difference in the log scale. This quantity is a natural result of:

- applying the log-transform to normalize the two cortisol variables;
- calculating the pre-minus-post dexamethasone difference in the log scale;
- performing the ANCOVA to obtain the adjusted mean difference and its confidence limits; and
- applying the reverse log transform to the adjusted mean differences and confidence limits.

Sample distributions of cortisol levels were summarized using means (nmol/Liter) and 95 percent confidence intervals (CI) across levels of PTSD symptom severity. PTSD and cortisol associations were adjusted for age, gender, smoking and alcohol consumption. Smoking, alcohol intake, and gender were included as dummy coded variables representing the categories listed in Table II. Age was included in the models as a continuous variable.

Results

Of the 100 randomly selected officers invited to participate, PTSD data were available for 92 officers and of these up to 75 officers had complete information also for cortisol and the covariates included in the analysis.

Although differences were not statistically significant, demographic characteristics of the participants (Table III) revealed the following: officers with severe PTSD symptoms were slightly older (46.2 years), had a higher BMI (31.4 kg/m^2) and were slightly more likely to report higher alcohol consumption (22.2 percent) compared to those with less severe PTSD symptoms.

Table II provides mean values of cortisol parameters across PTSD symptom categories adjusted for age, gender, smoking, and alcohol use. There were little differences between unadjusted and adjusted results. In participants with subclinical and mild categories of PTSD symptoms, cortisol levels increased after the high protein meal (Figure 1) and declined during the four subsequent 15-minute intervals in the expected fashion following an acute challenge. Participants with moderate and severe levels of PTSD symptoms exhibited a somewhat different pattern. Those with moderate PTSD symptoms had increases after the meal, but these cortisol levels remained high during the timed period instead of returning to a baseline level. Officers with severe PTSD symptoms showed a delayed response to the protein meal challenge

Table II.
Risk-factor adjusted mean cortisol parameters by PTSD symptom severity

Salivary cortisol parameters	PTSD symptom severity: Sub-clinical N	Sub-clinical Mean (95% C.I.)	Mild N	Mild Mean (95% C.I.)	Moderate N	Moderate Mean (95% C.I.)	Severe N	Severe Mean (95% C.I.)	p-value*	P_{trend}
Lunch challenge (nmol/l)										
Baseline	23	4.99 (3.54, 7.03)	24	5.79 (4.17, 8.03)	15	5.03 (2.91, 8.69)	9	4.75 (1.86, 12.10)	0.92	na
15 min	22	6.51 (4.60, 9.21)	24	7.10 (5.12, 9.86)	14	5.98 (3.43, 10.42)	9	4.95 (1.94, 12.62)	0.85	
30 min	23	6.48 (4.60, 9.13)	24	7.58 (5.46, 10.52)	15	7.66 (4.43, 13.24)	9	4.63 (1.82, 11.81)	0.71	
45 min	22	4.39 (3.10, 6.21)	24	6.27 (4.52, 8.70)	13	7.14 (4.07, 12.55)	9	3.18 (1.25, 8.11)	0.23	
60 min	23	4.67 (3.31, 6.58)	22	5.18 (3.71, 7.23)	14	7.07 (4.06, 12.32)	9	6.47 (2.54, 16.49)	0.60	
p-value*		0.03		0.06		0.36		0.08		
Awakening (nmol/l)										
1st waking	20	9.22 (6.06, 14.05)	24	7.87 (4.82, 12.85)	14	15.01 (8.85, 25.46)	8	7.75 (5.60, 10.75)	0.19	na
15 min	20	10.40 (6.83, 15.83)	23	8.43 (5.13, 13.86)	13	15.56 (9.03, 26.82)	8	10.86 (7.84, 15.04)	0.42	
30 min	20	8.23 (5.40, 12.53)	24	13.40 (8.04, 21.42)	12	13.12 (7.62,23.56)	8	10.94 (7.90, 15.16)	0.42	
45 min	20	7.34 (4.82, 11.17)	24	10.66 (6.53, 17.40)	14	8.15 (4.81, 13.83)	8	13.16 (9.50, 18.24)	0.11	
p-value*		0.05		0.22		0.17		0.03		
Mean awakening (nmol/l)	20	8.91 (6.22, 12.78)	24	9.53 (6.85, 13.25)	14	12.29 (8.10, 18.67)	8	11.50 (6.46, 20.47)	0.61	0.32
Bedtime (nmol/l)	20	1.40 (0.82, 2.39)	28	1.45 (0.92, 2.28)	17	2.78 (1.60, 4.85)	8	1.28 (0.55, 2.98)	0.21	0.81
Diurnal AUCg,(nmol/l)b	19	(3.79, 5.91) 4.73	22	6.08 (4.94, 7.48)	10	6.44 (4.81, 8.64)	6	6.49 (4.36, 9.67)	0.25	0.15
Diurnal Slope x 1000	21	(−4.04, −2.52) −3.28	29	−2.81 (−3.46, −2.15)	17	−1.90 (−2.70, −1.09)	8	−3.58 (−4.81, −2.35)	0.05	0.99
Dexamethasone Suppression Test Pre/Post ratio	17	(4.95, 17.58) 9.32	23	10.43 (6.10, 17.84)	10	6.86 (3.09, 15.21)	7	8.03 (3.06, 21.07)	0.82	0.62

Notes: Results adjusted for age, sex, smoking, and drinking beverages containing ethanol. *p-value for the difference between any of the means; a P_{trend}: p-value obtained from linear contrast test for trend; b-values are in thousands – AUCg: Area Under Curve Ground

Variable	PTSD symptom severity: Subclinical ($N = 25$)		Mild ($N = 36$)		Moderate ($N = 21$)		Severe ($N = 10$)		p-value[a]
Age (years)	43.5	(8.1)	43.0	(8.0)	43.3	(8.9)	46.2	(7.2)	0.35
BMI (kg/m2)	29.3	(4.4)	27.8	(4.7)	28.0	(4.9)	31.4	(12.0)	0.36
Education level (%)									0.74
Less than 12 Years	0.0		0.0		0.0		10.0		
High School/GED	12.0		16.7		14.3		10.0		
College < 4 years	28.0				33.3		40.0		
College 4 + years	60.0		25.0		52.4		40.0		
Cigarette smoking (%)									0.75
Never smoker	30.4		46.9		50.0		44.4		
Former smoker	52.2		31.2		38.9		44.4		
Current smoker	17.4		21.9		11.1		11.1		
Alcohol intake (%)									0.59
None	13.0		31.2		22.2		11.1		
Less than 1 drink/week	30.4		15.6		27.8		33.3		
1–7 drinks/week	47.8		34.4		44.4		33.3		
8 or more drinks/week	8.7		18.8		5.6		22.2		
Years of police service	15.4	(9.1)	13.8	(9.7)	14.2	(8.4)	14.1	(9.1)	0.75
Impact of events score	3.4	(3.1)	18.5	(5.1)	33.8	(4.7)	47.7	(3.2)	NA
Intrusive score	1.4	(2.2)	8.7	(4.9)	15.7	(4.4)	24.6	(4.7)	NA
Avoidance score	2.0	(2.2)	9.8	(4.5)	18.1	(3.9)	23.1	(3.0)	NA
Men (%)	68.0		52.8		57.1		50.0		0.64
Ethnicity (%)									0.57
European-American	76.0		83.3		61.9		70.0		
African-American	20.0		13.9		28.6		20.0		
Hispanic-American	4.0		3.8		9.5		10.0		

Notes: PTSD = Post-traumatic stress disorder; BMI = body mass index; BP = blood pressure. Values are means with standard deviations in parentheses or percentages. [a] For continuous variables the p-values are from tests for linear trend across PTSD severity; for categorical variables the p-values are from Fisher's exact tests of independence between the rows and columns of the frequency table

Table III.
Physiologic, lifestyle and demographic characteristics by PTSD symptom severity

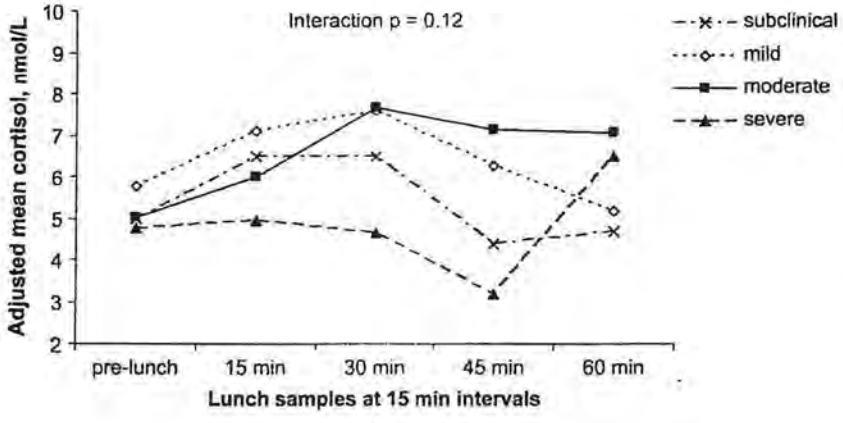

Figure 1.
Lunch cortisol response by PTSD severity model estimates, covariate adjusted

with little increase in cortisol levels after the meal and a sharp increase at the 60-minute level.

In general, participants with subclinical and mild PTSD symptoms displayed the expected cortisol pattern at awakening (Figure 2) with low initial values followed by a rise and fall. However, those officers with severe PTSD symptoms showed a pattern in which cortisol levels increased over the collection period and remained elevated. Those with moderate symptoms showed a pattern that was elevated at waking and then decreased; cortisol levels remained higher for a longer period of time before decreasing than did those with less severe PTSD symptoms. The first awakening mean cortisol level did not vary significantly across PTSD categories, although officers in the moderate category tended to have higher values. There was a statistically significant difference between first awakening and the 45-minute cortisol samples in the severe PTSD symptom category ($p = 0.03$) indicating a meaningful rise in cortisol levels after awakening without the expected decrease. The group by sample-time interaction effect was close to significance ($p = 0.12$) for the lunchtime challenge (Figure 1), testing the hypothesis that cortisol patterns across time are parallel between PTSD groups. Cortisol responses to the lunchtime challenge in severe PTSD categories were noticeably flatter than those in less severe categories, and moderate responses tended to stay elevated compared to the other categories. Similarly, a statistically significant interaction ($p = 0.008$) was found for the awakening cortisol response (Figure 2).

PTSD symptoms and the diurnal cortisol response

In general, cortisol levels decreased across the day but the diurnal cortisol response (Table II) suggested an increasing trend in cortisol levels across subclinical to severe PTSD symptom categories respectively ($p = 0.15$ test for trend). The total amount of daily cortisol secretion as reflected by the diurnal AUCg was highest in the severe PTSD symptom category. Those in the severe PTSD category not only had the highest daily secretion but also a steeper decline in cortisol as they moved toward the end of the day. This was also reflected in mean bedtime cortisol levels, which were lowest in those with severe PTSD symptoms.

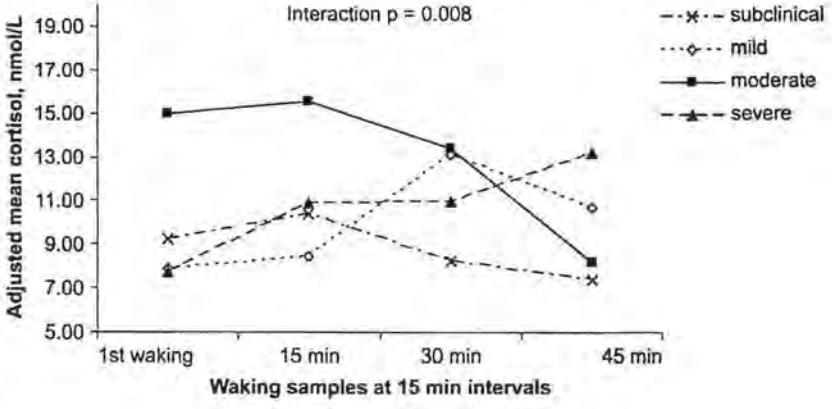

Figure 2.
Waking cortisol response by PTSD severity model estimates, covariate adjusted

PTSD symptoms and the DST

Cortisol suppression ratios, the ratio of the first awakening cortisol level on day two and the post-dexamethasone awakening cortisol on the morning of day three (Table II), appeared to be slightly lower in those reporting moderate or severe PTSD symptoms (6.86 and 8.03 respectively) than those reporting subclinical or mild symptoms (9.32 and 10.43 respectively).

Discussion

The strengths of this study included the availability of standardized cortisol samples adjusted for other risk factors, the use of a standardized protocol, and high response rates and cooperation. Cortisol assessment over a three-day period provided a reasonable sampling period, with a 92 percent compliance for complete saliva samples and the IES. The present study may serve to provide a guide for larger police population investigations on PTSD and physiological impact.

Our results suggest hypothalamus-pituitary-adrenal (HPA) dysregulation based on associations and interactions among reported PTSD symptoms and cortisol patterns found across cortisol parameters. Following the high protein lunchtime challenge, levels in officers with more PTSD symptoms did not respond in an expected pattern, that is, cortisol levels did not rise due to the high protein challenge and then return to a base level. This result differed from that of a previous study which found that cortisol levels in healthy individuals generally rose two to four times higher than baseline subsequent to a high protein meal challenge (Rosmond and Bjorntorp, 2000). In moderate PTSD categories, cortisol levels rose among officers and remained high during the 45-minute time span instead of returning to a basal level. Similar patterns were noted in the cortisol awakening measure. As such, our data suggest an inappropriate response of the HPA axis to several standard challenges for the moderate and severe PTSD group.

Cortisol patterns found in this study suggest "allostatic load", where failure to initiate or shut off mediators under conditions of chronic or acute stress leads to HPA dysregulation (McEwen and Seeman, 1999; McEwen, 1998, 2000, 2004). Other difficulties associated with traumatic stress exposure include HPA overreactivity, exaggerated startle response, sleep disruption, and nightmares. Events in police work may bring about a hypervigilance state, where officers experience an alteration in physiology, despite the absence of threat, and maintain a constant state of arousal (Yehuda, 2002, 2004; Yehuda *et al.*, 2004). Chronically traumatized people are hypervigilant, anxious, aggressive, and have no determinable baseline of psychological calm even after exposure to threatening situations has long ended (Yehuda, 2004). The residual impact of trauma may extend beyond a police career and include symptoms of acute generalized anxiety, worry, and depression. These symptoms contribute to a level of morbidity even after police officer retirement (Violanti and Paton, 1999). Our data would fit an allostatic load model in that those exhibiting higher levels of PTSD are under higher allostatic load and therefore their HPA axis is not operating in a healthy manner.

Our diurnal cortisol data also provides support for the idea that the HPA axis is not functioning efficiently in the officers displaying increased PTSD symptoms. Covariate-adjusted diurnal (whole day) cortisol levels indicated a nearly significant ($p = 0.15$) increasing trend as PTSD increased in severity, suggesting that officers

with increased PTSD symptoms may be experiencing increased activation of the HPA axis throughout the entire day. Whole day cortisol secretion levels in officers with severe PTSD symptoms did not appear to return to basal levels as readily as those who experienced lower PTSD symptom levels. Other investigations have also noted aberrant functioning of the HPA axis in those suffering from PTSD or displaying PTSD symptoms. Yehuda and McFarlane (1997) found that physiologic responses fail to return to the baseline, pre-trauma state in PTSD patients. In patients with long-term PTSD, findings suggest that the stress response is chronic and that the biological response is different from responses in normal subjects and patients with major depressive disorders (Yehuda, 2002; Otte *et al.*, 2005).

Previous studies have reported results contrary to the present findings. Yehuda (2004) suggested that 24-hour cortisol levels were actually lower in PTSD patients. Our findings suggested that cortisol is higher, not lower, through the diurnal cycle in those who report high PTSD symptoms. Others have also suggested that greater suppression of cortisol in PTSD patients as measured by DST occurs as a result of enhanced negative feedback processes (McEwen, 2004; Yehuda, 2001, 2004). We found that DST suppression ratios were less in those with higher PTSD symptoms.

There are several issues that may account for differences among cortisol-PTSD studies. The first is measurement. Our cortisol sample measure was obtained from saliva instead of urine or blood samples, allowing for an efficient immunoassay of unbound cortisol. The DST was expressed somewhat differently than other studies, calculating the ratio of the first waking cortisol level to the post dexamethasone first waking value. We viewed a ratio approach as having well known statistical properties that can be more clearly interpreted than other analytical techniques. We measured cortisol responses across levels of PTSD, a somewhat different approach than measuring PTSD versus non PTSD samples. This approach may be useful in helping to determine thresholds of physiological response. Although our measure of PTSD involved reported symptoms and not actual diagnoses, the IES is based on norms from diagnosed PTSD cases. It is acknowledged that IES captures intrusive and avoidance symptomatology, which renders usefulness as a measure for post-traumatic stress (Weiss and Marmar, 1997). Both the intrusion and avoidance scales of the IES have displayed acceptable reliability (Chronbach alpha of 0.79 and 0.82, respectively), and a split-half reliability for the whole scale of 0.86 (56). The IES has also displayed the ability to discriminate between varieties of traumatized groups from non-traumatized groups (Weiss *et al.*, 1997).

A second factor in study differences involves expected normal cortisol patterns. Stone *et al.* (2001) for example, found that a proportion of profiles in a normal healthy population are flat (51 percent had typical cycles, 17 percent flat cycles and 34 percent inconsistent cycles). Individual differences are large, and day-to-day stability is only modest. Curves vary with time, place and mode of awakening. The shape of a cortisol curve may be indicative of a long-term response to chronic stress or a variant within the normal range (Stone *et al.*, 2001).

The use of different populations is a third factor. Many studies on PTSD and cortisol rely on other populations who have experienced specific instances of trauma such as rape or auto accidents (Resnick *et al.*, 1993; Delahanty *et al.*, 2000) while police exposure to trauma may be multifaceted. The police have not yet been fully studied in terms of biological responses to trauma and little is known of the biological effects of

either direct or the threat of direct exposure to trauma among police officers. Of note is recent work by Ramon *et al.* (2004) on the Dutch police who found a reduced volume of the hippocampus in officers with PTSD. Reduced hippocampal volumes have also been found with other PTSD populations as well as with many disorders and conditions including major depression and aging (Miller and O'Callaghan, 2005).

There may be additional modifying factors in this study which impacted PTSD and cortisol associations. Only a small number of officers (31 percent) in our sample reported moderate or severe PTSD symptoms while the remainder experienced subclinical or mild symptoms. However, officers who did report moderate or severe PTSD symptoms had mean IES scores of 33.8 (4.7 SD) and 47.7 (3.2 SD) respectively, considerably higher than other groups reported in the literature (Beaton *et al.*, 1999). Although, we do not have history of trauma exposure in our sample, prior trauma and intensity of the response to a traumatic event may increase levels of PTSD (Schnurr *et al.*, 2002). Stress reactions other than PTSD may mediate the relationship between trauma exposure and biological anomalies. Examples are comorbidity with other disorders, life events, chronic daily work stresses, or a direct result of experiences such as military combat (Friedman and Schnurr, 1995). Research on PTSD and major depression has indicated that PTSD comorbid with major depression is much more similar to PTSD alone and distinctly different from major depression alone (Schnurr *et al.*, 2002). Other research has suggested that PTSD may play an indirect rather than a direct role in HPA activation (Schnurr *et al.*, 2002).

Exposure to traumatic work events and major disaster events emphasizes the need to further investigate the impact of PTSD on police personnel as well as other first responder groups. Recent large scale events such as 9/11 and Hurricane Katrina present police officers with situations where causation, scale, distribution and complexity contribute to levels of trauma risk by presenting demands that exceed the level of resources generally available to deal with them (Gidron, 2002; Galea *et al.*, 2002). Terrorism, for example, has increased trauma risk in more fundamental ways. For example, officers must accommodate the legacy (e.g. increased levels of fear in the community, changes in security precautions, perceiving the world as increasingly threatening) of terrorism into their thinking. In short, the range of circumstances that today affect police officers' vulnerability to PTSD has increased dramatically and should be the subject of additional scientific investigation (Flin and Arbuthnot, 2002).

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