Posttraumatic Stress Symptoms and Subclinical Cardiovascular Disease in Police Officers

John M. Violanti
State University of New York at Buffalo

Michael E. Andrew and Cecil M. Burchfiel
National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention

Joan Dorn
State University of New York at Buffalo

Tara Hartley and Diane B. Miller
National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention

The present study examined associations of posttraumatic stress disorder (PTSD) symptoms with subclinical cardiovascular disease in police officers. A stratified sample of 100 police officers was randomly selected from the Buffalo, New York, Police Department. Cardiovascular disease biomarkers were assessed by ultrasound of the brachial artery (flow-mediated dilation [FMD]). PTSD symptoms were measured with the Impact of Event Scale (IES). FMD was lowest in the severe PTSD symptom category when compared to the mild PTSD symptom category (1.91 vs. 5.15% increase, respectively; $p = .21$) even after adjustment for lifestyle and demographics. In conclusion, higher PTSD symptomatology in this police sample was associated with a nearly twofold reduction in brachial artery FMD, a biomarker for subclinical cardiovascular disease.

Keywords: police, posttraumatic stress disorder, cardiovascular disease, psychosocial risk factors

John M. Violanti and Joan Dorn, Department of Social and Preventive Medicine, State University of New York at Buffalo; Michael E. Andrew, Cecil M. Burchfiel, Tara Hartley, and Diane B. Miller National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

This work was supported by the National Institute for Occupational Safety and Health (NIOSH) Contract no. HELD01B0088. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

Correspondence concerning this article should be addressed to John M. Violanti, Department of Social and Preventive Medicine, State University of New York at Buffalo, 270 Farber Hall, Buffalo, NY 14214. E-mail: violanti@buffalo.edu

International Journal of Stress Management
2006, Vol. 13, No. 4, 541–554

1072-5245/06/$12.00 DOI: 10.1037/1072-5245.13.4.541

Data from the National Comorbidity Survey indicates that 60% of men and 50% of women are exposed to a traumatic event at some time in their lives (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Such exposure may involve actual or threatened death, serious injury, threat to one's physical integrity, or witnessing such events occurring to other persons or significant others. The essential feature of posttraumatic stress disorder (PTSD) is the development of characteristic symptomatology, including reexperiencing the event, avoidance of stimuli associated with the trauma, numbing of general responsiveness, and symptoms of increased arousal (American Psychiatric Association, 1994). The police occupation offers an excellent opportunity to study a population exposed to traumatic events. In number, the police population represents approximately 708,000 sworn officers in the United States alone (Reaves, 2002).

Selye (1984) recognized police work as one of the most stressful occupations in the world. Officers may thus have an increased risk for disease in this psychologically stressful occupation. Examples of traumatic occurrences include shootings, physical assault, witnessing violence and familial abuse, handling dead bodies, and disaster scenes such as on September 11, 2001 (Paton & Smith, 1996; Wilczak, 2002). Multiple exposures to such trauma increase the risk for subsequent health problems and psychological disorders and are related to increased symptoms of PTSD (Stephens, Long, & Flett, 1999). These high-risk situations can stimulate reinforcing physiological excitatory states (Paton & Violanti, 1997).

POLICE AND CARDIOVASCULAR DISEASE

Mortality studies indicate an elevated risk of atherosclerotic heart disease in police officers. Atherosclerotic heart disease, for example, has been found to be higher in officers with fewer years of service, yet is infrequently found in healthy worker populations (Violanti, Vena, & Petralia, 1998). Police officers have been found to be at elevated risk for atherosclerotic heart disease: 76% had elevated cholesterol; 26% had elevated triglycerides; and 60% elevated body fat composition (Franke, Cox, Schultz, & Anderson, 1997). Public safety officers had a higher probability of developing coronary heart disease than did the Framingham study population (Franke et al., 1997). A 22-year follow-up study of 970 Helsinki police officers found an association between hyperinsulinemia and increased coronary heart disease risk in police officers independent of other risk factors (Pyorala, Miettinen, Laakso, & Pyorala, 1998).

CARDIOVASCULAR DISEASE AND PTSD

PTSD may be a risk factor for cardiovascular problems, based on evidence that links stress-induced cardiovascular reactivity with changes in basal cardiovascular levels (Orr, Lasko, Shalev, & Pitman, 1995; Orr, Pitman, & Laskotterr, 1993). Recent studies describe a positive relationship between PTSD and cardiovascular problems, including higher rates of angina, lower cardiovascular effort tolerance on a treadmill test, and electrocardiogram abnormalities (Shalev, 1999). Evidence linking cardiovascular disease (CVD) and exposure to trauma has been found across different populations and stressor events. Military veterans diagnosed with PTSD, for example, were significantly more likely to have had abnormal electrocardiographic results, including a higher prevalence of myocardial (Q-wave) infarctions and atrioventricular conduction defects (Boscarino, 2004). Civilian populations exposed to traumatic events also have reported increased cardiovascular health problems (Buckley et al., 2004).

The present paper describes findings from the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) pilot study concerning the association between PTSD symptoms and standardized measures of brachial artery reactivity and carotid artery intima-media thickness (IMT) in police officers.

METHOD

Police Participants

The Buffalo, NY, Police Department, an urban police force of 934 officers, was the selected sample site. Details of the design and methods have been reported previously (Violanti et al., 2006). A random sample stratified on gender (n = 100) was generated from all police officers in the department using a computer-generated random number table. No specific inclusion criteria were used for the study, other than the participant would be a sworn police officer and willing to participate in the study. Seven participants with the following conditions were excluded from brachial ultrasound scanning: Raynaud's syndrome (n = 2), prior myocardial infarction (n = 1), cardiac pacemaker (n = 1), hypertension (n = 1), sprained wrist (n = 1), and patient discomfort (n = 1). Among the remaining 93 participants, 12 additional brachial scans were excluded since they were not of sufficient quality to be read due to participant movement or poor tape recordings, leaving 81 participants with adequate brachial scans. Carotid ultrasound exclusions included one officer with a previous myocardial infarction, six with inadequate scans due to anatomic reasons (e.g., increased carotid artery depth), and in one case the scan was of insufficient quality, leaving 93 participants with valid carotid scans. One participant had missing PTSD data, yet complete brachial and IMT data, and thus was excluded from most analyses. In sum, 77 officers had complete data for all three key measurements (PTSD, brachial reactivity, and IMT).

Testing Site

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. High resolution B-mode ultrasound using a 10–13 MHz transducer was used to evaluate flow-mediated dilation (FMD) and IMT. Ultrasound participants were screened for smoking, use of alcoholic and caffeinated beverages, and exercise six hours prior to ultrasound testing. Testing took place in a quiet, temperature-controlled room. Participants were allowed to rest comfortably for a period of 10 minutes prior to scanning and all were tested at approximately the same time of the day during their clinic visit.

Brachial Reactivity

Brachial reactivity represents a useful composite measure of overall vascular status (Vogel, 2001). The overall concept was to observe changes in artery dilation following the use of occlusive pressure on the artery, which causes reactive hyperemia in the vessel and dilation upon deflation of the cuff. A blood pressure cuff was inflated at forearm level at a pressure of 40 mmHg above the participant's resting systolic blood pressure (no higher than 230 mmHg) for a period of four minutes and rapidly released. Measures of vasodilatory responses obtained were the maximal dilation of the artery during the period of deflation and percentage change in arterial diameter compared to baseline diameter. A continuous scan was employed to maintain the probe at the same location and angle of interrogation throughout the scan without being removed from the skin surface. The scans were read at Wake Forest Ultrasound Reading Center, Wake Forest University, NC. Mandated quality control protocol at the Wake Forest Center requires blind comparison of four different representative scans selected by each reader and these readings were required to meet a criteria level of $<1.5\%$ coefficient of variation.

Carotid Intima-Media Thickness

Carotid IMT has been demonstrated to be a useful tool in predicting CVD outcomes, clinical coronary outcomes, and in monitoring the progression of arterial wall thickness over time (Chambless et al., 2000). The locations along the artery that were scanned in this study were the near and far walls of the right and left common carotids, carotid bifurcation, and the internal carotid artery (found to be a common site for the occurrence of lesions and atherosclerotic plaque). Images were taken in 1 cm segments from the tip of the flow-divider at the bifurcation of the carotid artery. Measures of the 1 cm segment of the common carotid prior to the bifurcation, the 1 cm of the bifurcation, and 1 cm of the internal carotid were obtained. The outcome variables for carotid artery analyses were the mean common carotid artery IMT and the mean maximum IMT. Images of both brachial reactivity and carotid IMT were recorded on high-resolution videotapes for interpretation. Readers were blinded to specific hypotheses and characteristics of the study population.

PTSD Symptoms

The Impact of Event Scale (IES) was used to measure psychological symptoms of PTSD (Horowitz, Wilner, & Alverez, 1979). It is widely acknowledged that IES captures intrusive and avoidance symptomatology, which renders its usefulness as a measure for posttraumatic stress (Beaton, Murphy, Johnson, Pike, & Corniel, 1999; Weiss & Marmar, 1997). The IES consists of 15 items, which evaluate experiences of avoidance and intrusion related to the intensity of posttraumatic stress. The measure was employed to assess PTSD symptoms in general and not in reference to a specific incident. The measure introduction question is phrased "Below is a list of comments made by people after stressful events. Please check each item, indicating how frequently these comments were true for you during the past seven days. If they did not occur during that time, please mark not at all (0)." Respondents were asked to rate items on a 4-point scale according to how often each had occurred in the past seven days: 0 (*not at all*), 1 (*rarely*), 3 (*sometimes*), and 5 (*often*). Seven of the items measure intrusive symptoms (intrusive thoughts, nightmares, intrusive feelings, and imagery), and the remaining eight items measure avoidance symptoms (numbing of responsiveness, avoidance of feelings, situations, ideas), and combined provide a total subjective score of traumatic stress symptomatology. The IES has also displayed the ability to discriminate a variety of traumatized groups from nontraumatized groups (Briere, 1997). The IES was categorized based on the mean IES score of a norm group of previously diagnosed PTSD patients admitted for treatment, $M = 35.3$; $SD = 17.2$ (Beaton, 1999; 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. The following levels of PTSD symptomatology were employed: 0–8 (subclinical); 9–25 (mild); 26–43 (moderate); and $\geq$44 (severe). IES, FMD, and IMT data were collected from participants during the same clinic visit.

Statistical Analysis

The sample distributions of PTSD, subclinical CVD, and covariates were summarized using means and standard deviations for continuous variables and percentages for categorical variables. Covariates including age, gender, education level, cigarette smoking, and alcohol intake were also examined by PTSD symptom severity. Hypertension status, diabetes status, total serum cholesterol level, and cholesterol lowering medication were also assessed. Unadjusted and adjusted mean brachial response and carotid IMT were calculated using analysis of covariance models performed with Process General Linear Models (PROC GLM) in Statistical Analysis Systems (SAS) version 9.1. All categorical covariates were coded with zero/one indicator variables and entered into the models as quantitative covariates. Age was included in the model as a continuous variable. All significance tests and reported p values were obtained using F statistics from the analysis of covariance (ANCOVA) models.

Informed Consent and Data Security

All participant officers in the study were informed of the purpose and benefits of the project, the research methods to be used, the potential risks or hazards of participation, and the right to ask for further information at any time during the research procedure. They were further informed that their choice to participate was a voluntary one, and they were free to withdraw from the research project at any time. 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.

RESULTS

Demographic characteristics of the participants are provided in Table 1 categorized by gender. Nearly half of the sample was between 40 and 49 years of age ($M = 44$ years); 19% were African American; and 42% were women due to their oversampling. Nearly 50% of officers in the sample had served more than 15 years in the department; 45% were current smokers; and nearly half the sample consumed alcohol less than one time per week.

Distributions of the variables in this study were compared for participants who had both subclinical CVD measures available (brachial reactivity and IMT) and those who were missing one or both of these variables. Compared with participants having complete measurements, those who were missing one or both markers for subclinical CVD tended to be similar for

Table 1. Demographic and Lifestyle Characteristics by Gender, BCOPS Baseline Study, 2001–2003

	Men ($N = 58$)		Women ($N = 42$)		Total ($N = 100$)	
Characteristic	*n*	%	*n*	%	*n*	%
Age group						
< 40 years	20	34.5	9	21.4	29	29.0
40–49 years	19	32.8	26	61.9	45	45.0
50 + years	19	32.8	7	16.7	26	26.0
Ethnicity						
European-American	44	75.9	32	76.2	76	76.0
African-American	9	15.5	10	23.8	19	19.0
Hispanic-American	5	8.6	0	0.0	5	5.0
Education[a]						
Less than 12 years	1	1.7	0	0.0	1	1.0
High School/GED	8	13.8	7	16.7	15	15.0
College < 4 years	17	29.3	12	28.6	29	29.0
College 4 + years	32	55.2	23	54.8	55	55.0
Years served[a]						
1–5 years	11	19.0	8	19.0	19	19.0
6–10 years	6	10.3	6	14.3	12	12.0
11–15 years	12	20.7	11	26.2	23	23.0
15+ years	29	50.0	17	40.5	46	46.0
Cigarette smoking status[a,b]						
Never	5	10.0	10	27.0	15	17.2
Former	18	36.0	15	40.5	33	37.9
Current	27	54.0	12	32.4	39	44.8
Alcohol intake[a,b]						
None	8	16.0	13	35.1	21	24.1
Less than 1 drink/week	11	22.0	10	27.0	21	24.1
1–7 drinks/week	22	44.0	12	32.4	34	39.1
8 or more drinks/week	9	18.0	2	5.4	11	12.6

Note. BCOPS = Buffalo Cardio-Metabolic Occupational Police Stress.
[a] Assessed during previous visit (years 1999–2000). [b] Ascertained for 87 participants.

Table 2. Anthropometric and Cardiovascular Characteristics by Gender, BCOPS Baseline Study, 2001–2003

Characteristic	Men (N = 43)		Women (N = 34)		Total (N = 77)	
	M	SD	M	SD	M	SD
Age (years)	44.1	9.0	44.0	5.8	44.0	7.8
BMI (kg/m^2)	28.6	3.4	27.5	5.1	28.1	4.3
Systolic BP (mm Hg)	122.0	13.1	113.7	13.5	118.3	13.9
Diastolic BP (mm Hg)	79.9	6.8	73.5	8.7	77.1	8.3
Heart rate (beats/min)	59.8	8.3	62.5	7.1	61.0	7.9
Impact of events score	18.3	13.4	21.2	13.9	19.6	13.6
Intrusive score	8.1	7.3	10.2	17.4	9.0	7.4
Avoidance score	10.1	7.5	11.0	7.7	10.5	7.5
Brachial artery diameter						
Baseline (mm)	4.90	0.51	3.71	0.49	4.37	0.7
Pre-cuff release (mm)	4.95	0.52	3.72	0.52	4.41	0.8
Maximum post-cuff release (mm)[a]	5.11	0.50	3.87	0.51	4.56	0.7
Carotid IMT (mm)	0.66	0.12	0.63	0.09	0.65	0.1
Carotid maximum IMT (mm)	0.87	0.16	0.82	0.14	0.85	0.1

Note. BCOPS = Buffalo Cardio-Metabolic Occupational Police Stress; BMI = body mass index; BP = blood pressure; IMT = intima-media thickness.
[a] Estimated using nonparametric regression for each subject's brachial curve.

most characteristics, yet had a significantly higher total mean IES score (19.6 and 26.8, respectively; p = .04) and accordingly also had a higher percentage of participants with severe PTSD symptoms (data not shown).

Table 2 provides mean levels and percentages of anthropometric and subclinical CVD measures for the 77 male and female police officers with complete data. Mean BMI and systolic and diastolic blood pressure were somewhat higher in men than in women, while mean heart rate was slightly lower in men than in women. Mean scores of the IES were higher for women officers. Mean scores on IES subscales of intrusiveness of thoughts and avoidance were slightly higher for women than men officers. Mean brachial FMD increased from 4.90 mm to 5.11 mm (4.29%) in men and 3.71 mm to 3.87 mm (4.31%) in women, as measured from baseline to maximum dilation. Mean carotid IMT was 0.66 mm in men and 0.63 mm in women officers.

Table 3 provides characteristics of the sample by PTSD level. The Cronbach's alpha for total IES scores was 0.91. Although differences were not statistically significant, there was a tendency for age and resting heart rate to increase with increasing PTSD symptom severity.

Table 4 provides absolute and percent differences from baseline to maximum dilation and IMT measures categorized by levels of PTSD symptoms. A twofold relative difference in FMD percent increase was observed between subclinical and severe PTSD symptom categories (5.15 vs. 1.91% increase, respectively), with dilation being the lowest in the severe symptom

Table 3. Physiologic, Lifestyle and Demographic Characteristics by PTSD Symptom Severity

Variable	PTSD symptom severity				
	Subclinical (N = 21)	Mild (N = 33)	Moderate (N = 18)	Severe (N = 5)	p-value[†]
Age (years)	43.1 (8.5)	42.9 (7.6)	45.5 (6.7)	49.4 (8.2)	0.07
BMI (kg/m^2)	28.1 (4.2)	27.5 (7.6)	29.1 (4.6)	28.5 (3.2)	0.67
Systolic BP (mm Hg)	119.7 (12.3)	115.2 (12.2)	124.0 (18.1)	113.5 (7.2)	0.63
Diastolic BP (mm Hg)	80.6 (8.7)	75.7 (7.8)	75.9 (8.7)	75.3 (5.3)	0.21
Heart rate (beats/min)	58.7 (8.4)	61.3 (6.3)	61.9 (8.3)	65.2 (12.8)	0.10
Education level (%)					0.37
Less than 12 years	0	0	0	0	
High School/GED	9	15	28	0	
College < 4 years	24	30	17	60	
College 4+ years	67	55	55	40	
Smoking status (%)					0.71
Never smoker	35	52	60	60	
Former smoker	20	17	7	0	
Current smoker	45	31	33	40	
Alcohol intake (%)					0.48
None	15	31	33	0	
Less than 1 drink/week	35	17	27	60	
1–7 drinks/week	40	31	33	20	
8 or more drinks/week	10	21	7	20	
Years of police service	14.7 (8.6)	13.6 (9.4)	17.2 (8.5)	16.4 (12.0)	0.53
Impact of events score	3.8 (3.2)	18.0 (5.1)	33.1 (5.4)	47.4 (3.5)	NA
Intrusive score	1.7 (2.3)	8.0 (4.4)	15.6 (4.8)	23.4 (5.2)	NA
Avoidance score	2.1 (2.2)	10.1 (4.3)	17.6 (4.1)	24.0 (3.2)	NA
Men (%)	62	52	61	40	0.78
Ethnicity (%)					0.54
European-American	81	82	67	100	
African-American	14	15	28	0	
Hispanic-American	5	3	6	0	

Note. Values are means with standard deviations in parentheses or percentages. PTSD = Posttraumatic Stress Disorder; BMI = body mass index; BP = blood pressure; NA = not applicable.

[†] For continuous variables the p values are from tests for linear trend across PTSD symptom severity; for categorical variables the p values are from exact tests of independence between the rows and columns of the frequency table.

category. The overall p value assessing unadjusted percent differences across the four PTSD symptom categories was 0.21. With adjustment for age and gender, differences across PTSD symptom categories were not altered appreciably. With further adjustment for education, smoking, and alcohol intake, these differences were attenuated somewhat (4.91 vs. 3.03% increase in brachial artery dilation). We also performed this analysis using the IES as a continuous variable with similar results, although they were less descriptive than with analysis of variance (ANOVA). The unadjusted regression showed a weak decreasing trend for FMD percent as IES increased (regression slope = -0.03; $p = .29$). Similar to the

Table 4. Unadjusted and Adjusted Brachial Artery Reactivity and Carotid IMT Values by PTSD Subgroup

	Absolute increase in arterial dilation (mm)			Percent increase in arterial dilation (%)			Carotid IMT (mm)		
PTSD severity	Unadjusted	Age and gender adjusted	Covariate adjusted[a]	Unadjusted	Age and gender adjusted	Covariate adjusted[a]	Unadjusted	Age and gender adjusted	Covariate adjusted[a]
Subclinical (N = 21)	0.22 (0.18)	0.22	0.21	5.15 (4.12)	5.13	4.91	0.67 (0.11)	0.67	0.67
Mild (N = 33)	0.17 (0.11)	0.17	0.17	4.17 (2.69)	4.12	4.06	0.63 (0.12)	0.64	0.64
Moderate (N = 18)	0.22 (0.13)	0.22	0.23	4.99 (3.10)	5.06	5.40	0.64 (0.11)	0.63	0.64
Severe (N = 5)	0.09 (0.15)	0.10	0.14	1.91 (4.53)	2.06	3.03	0.69 (0.08)	0.66	0.64

Note. Values are means with standard deviations in parentheses or percentages. Brachial reactivity is the absolute or percentage increase in brachial artery diameter compared with baseline diameter following release of a four-minute forearm cuff compression. IMT = intima-media thickness; PTSD = Posttraumatic stress disorder.

[a] Covariates include age, gender, education level, cigarette smoking and alcohol intake.

ANOVA results, this trend was attenuated (regression slope $= -0.01$; $p = .71$) after adjustment for age, gender, education, smoking, and alcohol intake. No significant differences were found in mean carotid and mean maximum IMT (data not shown for mean maximum IMT) across PTSD symptom categories for the unadjusted and covariate adjusted models.

DISCUSSION

A twofold relative percent change in brachial artery FMD as measured from baseline to maximum dilation was observed between subclinical and severe PTSD categories, with dilation being lowest in the severe PTSD symptom category. Smaller but similar directional differences were noted between subclinical and mild or moderate PTSD symptom categories. Covariate adjusted statistical models attenuated these differences slightly. What is unique in the present study is that PTSD symptoms are modeled as a gradient response and therefore can represent a clearer view of the association of PTSD symptoms and cardiovascular outcome in police officers. The group analysis preformed here allowed a conceptual threshold result, where differing levels of PTSD symptoms may or may not have an impact on differing levels of subclinical cardiovascular biomarkers. Impaired endothelium-dependent artery regulation may lead to ischemia and possibly impaired coronary blood flow during mental stress. Endothelium-dependent artery regulation appears to be negatively influenced by reactivity to stress (Bult, 1996; Celermajer, Sorenson, Bull, Robinson, & Deanfield, 1994; Wennmalm, 1994).

Mean carotid IMT for this police sample was 0.65 mm. Both mean carotid and mean maximum IMT measures showed no statistically significant differences across categories of PTSD. The mean carotid IMT among police officers was slightly lower compared with other large population-based studies. Findings from the Atherosclerosis Risk in Communities (ARIC) study show a mean thickness of 0.72 mm in participants without stroke (baseline age 45–64 years), a population slightly older on average than the present police sample (mean age = 44 years). A review on IMT measurements in normal subjects found that the risk of first myocardial infarction increases with an IMT of 0.82 mm or more and the risk of stroke with a mean IMT of 0.75 mm or more. The median wall thickness for all ages in this sample ranged from 0.5–1.0 mm. A study on younger healthy subjects (age 37 ± 4 years) reported an average IMT thickness of 0.75 mm. Thus, comparison with these previous studies suggests that our police sample was somewhat less likely to have increased carotid thickness. However, prospective assessment of the rate of carotid IMT progression in relation to PTSD symptoms may be important to consider in future studies.

The risk for cardiovascular harm may be high in PTSD, where physiological disruption is a common feature. Failure to engage or shut off stress mediators such as cortisol is one example of such disruption. McEwen (2004) terms this "allostatic load," and it can produce wear and tear on the body and precipitate disease. Previous research suggests that other factors may affect the level of PTSD symptoms and subsequent health outcomes. Physiological factors such as abnormally low basal cortisol levels may be associated with the underlying pathology of PTSD. Besides the Hypothalamus-Pituitary Adrenal (HPA) axis, the other major system that mediates stress, the sympathetic nervous system, may also be dysregulated (Friedman & McEwen, 2004; Friedman & Schnurr, 1995; McEwen, 2004; Yehuda & McFarlane, 1997). Persons with PTSD show a greater sympathetic nervous system response to situations resembling the traumatic event, including cardiovascular, skin conductance, and electromyographic responses (Blanchard et al., 1982, 1998; McEwen, 2004). Changes in behavior due to trauma such as maladaptive coping (alcohol use, diet abuses, smoking) may also impact health (Schnurr & Green, 2004; Yehuda, 2002).

The present findings may help to provide a starting point for further inquiry into exposure to traumatic incidents at work and their association with health outcomes in police officers. Very little work presently exists in this area. The strengths of this study include the availability of standardized measures of subclinical CVD markers such as brachial FMD and carotid IMT along with other risk factors and psychosocial measures for this sample, the use of a standardized protocol, and high response rates and cooperation. Many previous studies of PTSD symptoms and health outcomes relied on self-reported assessments of health or medical diagnostic categories and not actual measures of cardiovascular artery function and structure (Schurr, Friedman, & Bernardy, 2002; Schnurr & Green, 2004).

Although the cross-sectional design of this study precludes causal inferences, the assessment of subclinical CVD at a single point in time provides descriptive health and psychological characteristics of officers in a midsized urban police department. In recent times, where the potential for PTSD has increased due to major events such as 9/11 and hurricane Katrina, the need for examination of objective health outcomes associated with PTSD becomes even more important (Galea, Ahern, & Resnick, 2002). Additional prospective research with larger populations and standardized measures of cardiovascular health is anticipated.

REFERENCES

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Beaton, R., Murphy, S., Johnson, C., Pike, K., & Corniel, W. (1999). Coping responses and posttraumatic stress symptomatology in urban fire service personnel. *Journal of Traumatic Stress, 12,* 293–308.

Blanchard, E. B., Kolb, L. C., Pallmeyer, T. P., & Gerardi, R. J. (1982). A psychophysiological study of post traumatic stress disorder in Vietnam veterans. *Psychiatric Quarterly, 54,* 220–229.

Blanchard, E. B., Kolb, L. C., & Prins, A. (1998). Psychophysiological responses in the diagnosis of posttraumatic stress disorder in Vietnam veterans. *Journal of Nervous & Mental Disorders, 79,* 99–103.

Boscarino, J. A. (2004). Posttraumatic stress disorder and physical illness: Results from clinical and epidemiological studies. *Annals of NY Academy of Science, 1032,* 141–153.

Briere, J. (1997). *Psychological assessment of adult posttraumatic states.* Washington, DC: American Psychological Association.

Buckley, B., Nugent, N., Sledjeski, E., Raimonde, A. J., Spoonster, E., Bogart, L. M., et al. (2004). Evaluation of initial posttrauma cardiovascular levels in association with acute PTSD symptoms following a serious motor vehicle accident. *Journal of Traumatic Stress, 17,* 317–324.

Bult, H. (1996). Nitric Oxide and atherosclerosis: Possible implication for therapy. *Molecular Medicine Today, 2,* 510–518.

Celermajer, D. S., Sorensen, K., Bull, C., Robinson, J., & Deanfield, J. E. (1994). Endothelium-dependent dilation in the systemic arteries of asymptomatic subjects relates to coronary risk factors and their interaction. *Journal of the American College of Cardiology, 24,* 1468–1474.

Chambless, L. E., Folsom, A. R., Clegg, L. X., Sharrett, A. R., Shahar, E., Nieto, F. J., et al. (2000). Carotid wall thickness is predictive of incident clinical stroke: The Atherosclerosis Risk in Communities (ARIC) Study. *American Journal of Epidemiology, 151,* 478–487.

Franke, W. D., Cox, D. F., Schultz, D. P., & Anderson, D. F. (1997). Coronary heart disease risk factors in employees of Iowa's department of public safety compared to a cohort of the general population. *American Journal of Industrial Medicine, 31,* 733–777.

Friedman, M. J., & McEwen, B. S. (2004). Posttraumatic stress disorder, allostatic load, and medical illness. In P. P. Schnurr & B. L. Green (Eds.), *Trauma and health: Physical health consequences of exposure to extreme stress* (pp. 157–188). Washington, DC: American Psychological Association.

Friedman, M. J., & Schnurr, P. P. (2002). The relationship between trauma, PTSD, and physical health. In M. J. Friedman, D. S. Charney, & A. Y. Deutch (Eds.), *Neurobiological and clinical consequences of stress: From normal adaptation to PTSD* (pp. 507–524). Philadelphia: Lippincott-Raven.

Galea, S., Ahern, J., & Resnick, H. (2002). Psychological sequelae of the September 11 terrorist attacks in New York City. *New England Journal of Medicine, 346,* 382–987.

Horowitz, M. J., Wilner, N., & Alvarez, W. (1979). Impact of event scale: A measure of subjective stress. *Psychosomatic Medicine, 41,* 209–218.

Kessler, R. C., Sonnega, A., Bromet, E., Hughes, M., & Nelson C. B. (1995). Posttraumatic stress disorder in the National Comorbidity Survey. *Archives of General Psychiatry, 52,* 1048–1060.

McEwen, B. S. (2004). Allostasis and allostatic overload and relevance to the pathophysiology of psychiatric disorders. *Annals of NY Academy of Science, 32,* 1–7.

Orr, S. P., Lasko, N. B., Shalev, A. Y., & Pitman, R. K. (1995). Physiologic responses to loud tones in Vietnam veterans with posttraumatic stress disorder. *Journal of Abnormal Psychology, 104,* 1–8.

Orr, S. P., Pitman, R. K., Lasko, N. B., & Herr, L. R. (1993). Psychophysiological assessment of posttraumatic stress disorder imagery in World War II and Korean combat veterans. *Journal of Abnormal Psychology, 102,* 52–59.

Paton, D., & Smith, L. M. (1996). Psychological trauma in critical occupations: Methodological and assessment strategies. In D. Paton & J. M. Violanti (Eds.), *Traumatic stress in critical occupations: Recognition, consequences, and treatment* (pp. 125–139). Springfield. IL: Charles C Thomas Publishing.

Paton, D., & Violanti, J. M. (1997). Chronic exposure to risk and trauma: Addiction and separation issues in police officers. *Police Psychology Symposium Publication.* Wellington, NZ: New Zealand Psychological Society.

Pyorala, M., Miettinen, H., Laakso, M., & Pyorala, K. (1998). Hyperinsulemia predicts coronary heart disease risk in healthy middle-aged men: The 22-year follow-up results of the Helsinki policemen study. *Circulation, 98,* 398–404.

Reaves, B. A. (2002). Census of state and local law enforcement agencies. *Bureau of Justice Statistical Bulletin, NCJ* 19602, *28,* 665–71. Washington, DC: U.S. Government Printing office.

Schnurr, P. P., Friedman, M. J., & Bernardy, N. C. (2002). Research on posttraumatic stress disorder: Epidemiology, pathophysiology, and assessment. *Psychiatric Practice, 58,* 877–889.

Schnurr, P. P., & Green, B. L. (2004). Understanding relationships among trauma, posttraumatic stress disorder, and health outcomes. In P. P. Schnurr & B. L. Green (Eds.), *Trauma and health: Physical health consequences of exposure to extreme stress* (pp. 247–275). Washington, DC: American Psychological Association.

Selye, H. (1984). Police stress. *Police Stress Magazine, 1,* 2–5.

Shalev, A. Y. (1999). Psychophysiological expression of risk factors for PTSD. In R. Yehuda (Ed.), *Risk factors for Posttraumatic Stress Disorder* (pp. 143–161). Washington, DC: American Psychiatric Press.

Stephens, C., Long, N., & Flett, R. (1999). Vulnerability to psychological disorder: Previous trauma in police recruits. In J. M. Violanti & D. Paton (Eds.), *Police trauma: Psychological aftermath of civilian combat* (pp. 65–74), Springfield, IL: Charles C Thomas Publisher.

Violanti, J. M., Burchfiel, C. M., Miller, D. B., Andrew, M. E., Dorn, J., Wactawski-Wende, J., et al. (2006). The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Pilot Study: Methods and participant characteristics. *Annals of Epidemiology, 16,* 148–156.

Violanti, J. M., Vena, J. E., & Petralia, S. (1998). Mortality of a police cohort: 1950–1990. *American Journal of Industrial Medicine, 33,* 366–373.

Vogel, R. A. (2001). Measurement of endothelial function by brachial artery flow-mediated vasodilation. *American Journal of Cardiology, 88 Suppl I,* 31–4.

Weiss, D., & Marmar, C. (1997). The Impact of Event Scale - Revised. In J. Wilson, & T. Keane (Eds.), *Assessing Psychological Trauma and PTSD.* New York: Guilford Press.

Wennmalm, A. (1994). Endothelial nitric oxide and cardiovascular disease. *Journal of Internal Medicine, 235,* 317–327.

Wilczak, C. (2002). Three perspectives on trauma from New York City police officers. *Div. 17 Newsletter 2002, 3,* 13–15.

Yehuda R. (2002). Post traumatic stress disorder. *New England Journal of Medicine, 246,* 108–114.

Yehuda, R., & McFarlane A. C. (1997). *Annals of the New York Academy of Sciences* (Vol. 821). New York: New York Academy of Sciences, 145–550.