

## Original Article

## Associations of Depressive Symptoms and Brachial Artery Reactivity among Police Officers

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**Objectives:** Mental health has been shown to be linked with certain underlying physiological mechanisms. The objective of this cross sectional study was to investigate the relationship between depressive symptoms and brachial artery reactivity (BAR) in an understudied population: police officers.

**Methods:** Participants were 351 police officers who were clinically examined in the Buffalo Cardio-Metabolic Police Stress (BCOPS) study. BAR was performed using standard B-Mode ultrasound procedures. Depressive symptoms were measured using the Center for Epidemiological Studies Depression (CES-D) scale. Mean values of the difference between the baseline and maximum diameters of the brachial artery were determined across three categories of CES-D score using the analysis of variance and the analysis of covariance. p-values for linear trends were obtained from linear regression models.

**Results:** The mean age ( $\pm$  standard deviation) of all officers was  $40.9 \pm 7.2$  years. Women had a slightly higher mean CES-D score than men ( $8.9 \pm 8.9$  vs.  $7.4 \pm 6.4$ ) and a slightly higher percentage increase of BAR than men (6.90 vs. 5.26%). Smoking status significantly modified the associations between depressive symptoms and BAR. Among current smokers, mean absolute values of BAR significantly decreased as depressive symptoms increased after adjustment for age, gender, race/ethnicity, hypertension, and diabetes; the multivariate-adjusted p-values were 0.033 (absolute) and 0.040 (%). Associations between depressive symptoms and BAR were not statistically significant among former smokers or never smokers.

**Conclusion:** Depressive symptoms were inversely associated with BAR among police officers who were current smokers and together may be considered a risk factor for cardiovascular disease among police officers. Further prospective research is warranted.

**Key Words:** Police, Depression, Cardiovascular diseases, Smoking, Occupational health

## Introduction

Policing in the United States presently consists of over 883,000

sworn officers which is expected to rise to a projected 968,000 officers by 2018 [1]. Police work is considered a stressful occupation which not only involves danger and traumatic event exposure, but also organizational stressors such as lack of administrative support, punishment centered executive philosophies, and excessive paperwork [2-6]. Such exposures can lead to behaviors and patterns associated with chronic stress. Sustained or chronic stress may lead to elevated hormones such as cortisol and reduced levels of serotonin and other neurotransmitters in the brain, including dopamine, which has been linked to de-

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pression [7].

When the stress response fails to shut off and is not properly reset after the difficult situation has passed, it can lead to depression [8,9]. Depression has been associated with increased risk of cardiovascular disease (CVD) [1-12]. Barefoot and Schroll [13] found that a high level of depressive symptoms predicted the subsequent occurrence of myocardial infarction and mortality in a 21-year follow up study. Appels and Mulder [14] found relationships between various negative psychological states and the occurrence of coronary heart disease. Krishnan et al. [15] estimated that at any given time, up to 20% of persons with heart disease also met the criteria for depression. Depression has also been associated with biological outcomes which exacerbate the risk of CVD, including hyperactivity within the hypothalamic-pituitary-adrenal axis, diminished heart rate variability, and ventricular instability [16,17].

Due to occupational exposure and increased risk for stress and depression, police officers may be at higher risk for CVD [18-20]. Hartley et al. [21] found an association between components of the metabolic syndrome and depressive symptoms among a police sample. The number of metabolic syndrome components increased significantly across categories of depressive symptoms for male officers ( $p$ -trend = 0.003). For each 5-unit increase in the depression score, odds for having hypertriglyceridemia increased by 47.6%, 51.8% for having hypertension, and 56.7% for having glucose intolerance.

In the present study, we tested associations between depressive symptoms and brachial artery reactivity (BAR), a subclinical marker of cardiovascular disease, among police officers. Subclinical markers are useful to assess early disease etiology because clinical manifestations occur primarily after the disease has advanced. BAR is a subclinical CVD measure of endothelial function which can be assessed by measuring the vasodilatory capacity of the artery where comparisons can be made with that of a normally functioning endothelium [22,23]. Endothelial dysfunction is one of the earliest markers of vascular deterioration and CVD [24-28]. The endothelium is the inner lining of blood vessels [29]. Endothelial dysfunction results from mechanical or chemical damage to the endothelium by various risk factors such as C-reactive protein [24]. Exploration of the brachial artery flow-mediated dilation (FMD) capability is the most commonly used method for assessing endothelial function [24]. FMD is a measure of vasodilation capability in response to a sudden increase in shear stress and endothelial dysfunction is reflected in an impaired FMD response [24].

Atherosclerosis and related CVD risk factors (such as smoking, hypercholesterolemia) are also associated with impaired BAR. In addition to physiological factors, depression

can lead to behavioral changes which may further exacerbate health problems. People who are stressed often neglect healthy lifestyle practices. They may smoke and drink more than normal [30]. Because the prevalence of cigarette smoking is higher among persons who are depressed compared with those do not suffer from depression [31] and smoking is also a strong risk factor for CVD [32], it is quite possible that the association between the Center for Epidemiological Studies Depression (CES-D) score and BAR may vary between smokers and non-smokers. Therefore, effect modification will be examined for smoking status. Other variables for which effect modification will be assessed include gender, body mass index (BMI), alcohol intake, physical activity, and sleep duration. Although this is a cross-sectional study, we hypothesized that depressive symptoms could result in endothelial dysfunction. Our objective was to examine whether depressive symptoms are associated with subclinical CVD (i.e., impaired brachial artery FMD) and the role of several demographic, lifestyle and other health factors in this association.

## Materials and Methods

### Study population

In 2004, 710 police officers from the Buffalo, New York Police Department were contacted and invited to participate in the Buffalo Cardio-metabolic Occupational Police Stress (BCOPS) study. This study was approved by the Health Sciences Internal Review Board, University at Buffalo, The State University of New York, and the National Institute for Occupational Safety and Health Human Subjects Review Board. During the recruitment phase which took place between June 2004 and October 2009, 464 police officers (active-duty and retired) agreed to participate. Prior to any clinic examinations, the officers reviewed and signed informed consent forms. Female officers who were pregnant at the time of examination were excluded. The data were collected at the Center for Health Research, School of Public Health and Health Professions, University at Buffalo, The State University of New York. To be eligible for this current study, officers must have had no prior history of heart attack, stroke, bypass surgery, carotid artery endarterectomy, transient ischemic attack, Raynaud's syndrome, diabetes with insulin pump, kidney dialysis, or any physician-diagnosed coronary heart disease. Officers were also excluded if they had retired prior to examination ( $n = 33$ ), or had missing information for BAR ( $n = 77$ ) and CES-D scale score ( $n = 3$ ). The final sample for our analyses included 351 officers with complete data (276 men and 75 women).

## Measures

### BAR

Five BAR measures were collected in the BCOPS study. They include the baseline diameter of the brachial artery (mm), the diameter after inflation but before release of the blood pressure cuff (mm), the maximum post-inflation diameter (mm), the absolute difference in diameter between the baseline and post-cuff release (mm), and the difference in diameter as a function of baseline diameter (%). Ultrasound scans of the brachial artery were performed using the Biosound Esaote AU5 ultrasound imaging machine (Esaote North America Inc., Indianapolis, IN, USA) with a 10 MHz transducer. Brachial artery diameter (over a 10 mm segment of the vessel) was defined for this study as the maximum distance between the “trailing edge” of the adventitia-media interface of the near wall (closest to skin surface) of the artery and the “leading edge” of the media-adventitia interface of the far wall of the vessel.

The level of occlusion pressure was controlled by cuff inflation on the forearm, to 40 mmHg above the participant's resting systolic blood pressure, with an upper limit of 230 mmHg. The protocol used for this study continuously imaged the brachial artery during a baseline period (1 minute), an occlusion period (4 minutes), and following cuff release (3 minutes). Even though there are a range of cuff inflations used, the standardized component of the protocol is that the level of inflation was consistent for each participant (systolic blood pressure plus 40 mmHg). Electrocardiogram tracings were visible on the image screen and recorded throughout the scan, enabling diameter measurements to be taken at the peak of the R-wave. Continuous B-mode images visualizing boundaries in the artery were obtained at the same location and angle of interrogation on the brachial artery for the 8 minute period of the scan. Scans were recorded on S-VHS videocassettes, and later digitized for reading on-site using Image-Pro Plus software (Media Cybernetics Inc., Bethesda, MD, USA). Ultrasound readers were also blinded regarding information about the participant's risk factors. Scans were randomly assigned to readers, and therefore each reader read approximately the same proportion of scans from each study.

A phantom scan, using a tissue equivalent phantom, was performed every 2 weeks to ensure instrument calibration. Ten percent of the scans were double-read, and the average percent difference in brachial artery diameter between 2 readers was 0.561% ( $r = 0.993$ , coefficient of variation = 1.72%); targeted difference for quality control was < 1.0%. Brachial FMD was computed with the formula: maximum diameter - baseline diameter/baseline diameter multiplied by 100. A larger baseline diameter would result in a smaller percentage of change and

smaller arteries dilate more than larger arteries [24]. Decreases in FMD % is indicative of endothelial dysfunction.

### Depressive symptoms

Depressive symptoms were measured using the CES-D scale. The CES-D is a short scale that was designed to measure symptoms of depression in the general population [33]. Several dimensions of depression are measured including affective components of depression, psychomotor retardation, loss of appetite, and sleep disorder. The CES-D consists of 20 items with responses on a 4-point scale which represents the degree to which each symptom occurred during the past seven days: 0 (rarely or none of the time, less than 1 day); 1 (some or little of the time, 1-2 days); 2 (occasionally or a moderate amount of time, 3-4 days); and 3 (most or all of the time, 5-7 days). These items are used to obtain an overall score of depressive symptoms. The CES-D score were categorized into three categories for analysis; 1st group (0-8), 2nd group (9-15), and 3rd group ( $\geq 16$ ).

### Assessment of covariates

Hypertension was defined as taking any medication for high blood pressure or having a systolic blood pressure of  $\geq 140$  mmHg or a diastolic blood pressure of  $\geq 90$  mmHg. Diabetes was defined as taking any medication for diabetes or having a fasting serum glucose level of  $\geq 126$  mg/dL [34]. Participants were weighed and height was measured without shoes. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Blood was collected from officers who had fasted for at least 12 hours the previous night. Blood parameters were measured at Kaleida Laboratory, Buffalo, NY, by standard laboratory techniques on the Beckman Coulter LX20 clinical chemistry analyzer (Beckman Coulter, Brea, CA, USA) and included chemistry panels for glucose.

Self and interviewer administered questionnaires were used to provide information on demographic characteristics, lifestyle behaviors, and medical history. For educational status, they checked one of eight choices from ‘less than 12 years of school’ to ‘graduate degree’; these eight categories were later collapsed into three levels (< high school/general educational development, college < 4 years, and college  $\geq 4$  years). Officers were asked how often they consumed alcoholic beverages with one drink defined as a 12-oz can or bottle of beer, one medium glass of wine (6 oz), or one shot (1 oz) of liquor. The total number of drinks per month (of each type) was summed and then divided by 4 to give the approximate total number of drinks consumed per week. Questions on smoking history included these questions: “During your entire life, have you smoked at least 100 cigarettes, that is, about 5 packs of cigarettes?” and

“Do you smoke cigarettes now?” Responses from these questions were used to categorize officers into one of three smoking groups: current, former, or never.

### Statistical analysis

Simple descriptive measures were calculated for all variables. Associations for all covariates with CES-D score and BAR

**Table 1.** Demographic and lifestyle characteristics by gender, 2004-2009

	Men (n = 276)		Women (n = 75)		Total (n = 351)	
Age (year)	276	41.0 ± 7.5	75	40.4 ± 6.1	351	40.9 ± 7.2
BMI (kg/m <sup>2</sup> )	274	30.3 ± 4.1	75	26.0 ± 4.8	349	29.3 ± 4.6
Duration of police service (year)	274	14.8 ± 7.8	75	13.3 ± 6.8	349	14.5 ± 7.6
Alcohol intake (drinks per week)	229	6.9 ± 10.4	53	4.6 ± 4.6	282	6.5 ± 9.6
Depressive symptoms (CES-D score)	276	7.4 ± 6.4	75	8.9 ± 8.9	351	7.7 ± 7.1
Brachial artery diameter measures						
Baseline (mm)	276	4.83 ± 0.68	75	3.63 ± 0.44	351	4.57 ± 0.80
Pre-cuff release (mm)	276	4.86 ± 0.69	75	3.64 ± 0.44	351	4.60 ± 0.82
Maximum post-cuff release (mm) <sup>†</sup>	276	5.07 ± 0.67	75	3.87 ± 0.44	351	4.82 ± 0.80
Maximum - baseline diameter	276	0.25 ± 0.12	75	0.24 ± 0.13	351	0.25 ± 0.12
Change in BAR (%)	276	5.26 ± 2.73	75	6.90 ± 3.73	351	5.61 ± 3.04
Age group (year)						
< 35	52 (18.8)		12 (16.0)		64 (18.2)	
35-39	69 (25.0)		22 (29.3)		91 (25.9)	
40-45	77 (27.9)		19 (25.3)		96 (27.4)	
≥ 45	78 (28.3)		22 (29.3)		100 (28.5)	
Race/ethnicity						
Caucasian	211 (77.0)		54 (72.0)		265 (75.9)	
African-American	51 (18.6)		21 (28.0)		72 (20.6)	
Hispanic-American	12 (4.4)		0 (0)		12 (3.4)	
Education						
≤ High school/GED	38 (13.9)		3 (4.0)		41 (11.7)	
College < 4 years	142 (51.8)		46 (61.3)		188 (53.9)	
College ≥ 4 years	94 (34.3)		26 (34.7)		120 (34.4)	
Cigarette smoking status						
Never	182 (66.4)		33 (45.2)		215 (62.0)	
Former	56 (20.4)		21 (28.8)		77 (22.2)	
Current	36 (13.1)		19 (26.0)		55 (15.8)	
Hypertension	72 (26.1)		9 (12.0)		81 (23.1)	
Diabetes	9 (3.3)		1 (1.3)		10 (2.8)	

Values are presented as number, mean ± standard deviation, or number (%).

<sup>†</sup>Estimated using non-parametric regression for each subject's brachial curve.

BMI: body mass index, CES-D: Center for Epidemiologic Studies Depression scale, BAR: brachial artery reactivity, GED: general educational development.

were examined using the chi-square test of independence and analysis of variance (ANOVA). Effect modification was examined for smoking status, gender, BMI, alcohol intake, physical activity, and sleep duration. If the p-value for the interaction term was significant, the association between CES-D score and

BAR was investigated while stratifying by the relevant variable. The criterion for statistical significance of effect modification was set at a p-value of 0.20. Variables were chosen as potential confounders a priori and/or based on their significant association with both the independent and dependent variables.

**Table 2.** Association of selected characteristics with BAR absolute values, 2004-2009

	BAR		
	All	Women	Men
Age (year)	-0.135, 0.011	-0.091, 0.436	-0.147, 0.014
BMI (kg/m <sup>2</sup> )	0.178, 0.741	-0.216, 0.063	0.097, 0.109
Alcohol intake (drinks per week)	0.079, 0.185	-0.001, 0.995	0.096, 0.148
Depressive symptoms (CES-D score)	0.034, 0.524	-0.131, 0.262	0.104, 0.085
Race/ethnicity			
Caucasian/ Hispanic-American	0.25 ± 0.12	0.25 ± 0.14	0.25 ± 0.11
African-American	0.22 ± 0.13	0.22 ± 0.08	0.22 ± 0.14
p-value <sup>†</sup>	0.036	0.217	0.116
Education			
≤ High school/GED	0.27 ± 0.11	0.34 ± 0.10	0.26 ± 0.11
College < 4 years	0.24 ± 0.12	0.23 ± 0.13	0.24 ± 0.12
College ≥ 4 years	0.25 ± 0.12	0.25 ± 0.12	0.25 ± 0.12
p-value*	0.484	0.272	0.678
Cigarette smoking status			
Never	0.25 ± 0.13	0.25 ± 0.15	0.25 ± 0.12
Former	0.25 ± 0.12	0.23 ± 0.11	0.25 ± 0.12
Current	0.24 ± 0.10	0.24 ± 0.12	0.24 ± 0.08
p-value <sup>†</sup>	0.961	0.812	0.925
Hypertension			
Yes	0.22 ± 0.11	0.23 ± 0.09	0.22 ± 0.11
No	0.25 ± 0.12	0.25 ± 0.13	0.26 ± 0.12
p-value <sup>†</sup>	0.024	0.733	0.017
Diabetes			
Yes	0.24 ± 0.08	- <sup>‡</sup>	0.24 ± 0.08
No	0.25 ± 0.12		0.25 ± 0.12
p-value <sup>†</sup>	0.890		0.803

Values for continuous variables are Pearson's correlation coefficients and associated p-values.

Values for categorical variables are means ± SD.

\*p-values were obtained from linear contrasts analysis of variance (ANOVA).

<sup>†</sup>p-values are for any differences between the means and were obtained from ANOVA.

<sup>‡</sup>Not reported due to small sample size: Yes (n = 1) and No (n = 74).

BAR: brachial artery reactivity, BMI: body mass index, CES-D: Center for Epidemiologic Studies Depression scale, GED: general educational development.

Potential confounders included age, gender, race/ethnicity, hypertension, and diabetes. Unadjusted and adjusted mean values of BAR were determined across three categories of CES-D score (0-8, 9-15, and  $\geq 16$ ) using ANOVA and analysis of covariance (ANCOVA). We chose the cut-point of  $\geq 16$ , since this is commonly used in clinical diagnoses, and then divided the remainder to obtain three groups having adequate sample size. p-values for linear trends were obtained from linear regression models. All analyses were conducted in SAS version 9.2 (SAS Institute Inc., Cary, NC, USA).

## Results

The mean age ( $\pm$  standard deviation) of all 351 officers was  $40.9 \pm 7.2$  years (Table 1). The majority of officers were Caucasian (75.9%) and 15.8% were current smokers. Approximately 23% of all officers had a history of hypertension, 2.8% a history of diabetes, and the prevalence of both conditions was higher among men. Women had a slightly higher mean CES-D score than men ( $8.9 \pm 8.9$  vs.  $7.4 \pm 6.4$ ) and a slightly higher mean percentage increase in diameter between the baseline and maximum values of BAR than men (6.90 vs. 5.26%). The associations of selected covariates with BAR are presented in Table 2.

Age was inversely correlated with BAR ( $r = -0.135$ ,  $p = 0.011$ ) and this correlation was only significant among men ( $-0.147$ ,  $0.014$ ). Officers who were not hypertensive had higher mean absolute values of BAR than those who were hypertensive (0.25 mm vs. 0.22 mm;  $p = 0.024$ ) with the association being statistically significant among men only. None of the

covariates listed in Table 2 were significantly associated with CES-D score (data not shown). Mean values for absolute and percent increase of BAR are presented across three categories of depressive symptoms (CES-D score) (Table 3). The results showed no significant associations between depressive symptoms and BAR.

In Table 4, mean values for absolute and percent increase of BAR are presented across three categories of depressive symptoms (CES-D score) and stratified by smoking status. Smoking status significantly modified the associations between depressive symptoms and BAR; interaction  $p = 0.039$  (absolute BAR) and  $p = 0.037$  (% BAR). Among current smokers, mean absolute values of BAR significantly decreased with increasing scores of depressive symptoms after adjustment for age, gender, race/ethnicity, hypertension, and diabetes; the multivariate-adjusted p-values were 0.033 (absolute increase in BAR) and 0.040 (% increase in BAR). The associations between depressive symptoms and BAR were not statistically significant among former smokers or never smokers. Of all the variables that were assessed for effect modification, only smoking status and gender were statistically significant. We chose not to present the gender-stratified results because the associations between CES-D score and BAR were not statistically significant among either women or men. Associations between depressive symptoms and BAR did not vary across levels of alcohol intake, BMI, physical activity, or sleep duration, nor were the interaction terms associated with these variables significant.

**Table 3.** Mean values of absolute and percent increase in BAR diameter by three groups of depressive symptoms (CES-D score); 2004-2009

	Depressive symptoms (CES-D score)			p-value
	CES-D 0-8 (n = 237)	CES-D 9-15 (n = 76)	CES-D $\geq 16$ (n = 38)	
BAR (absolute increase, mm)				
Model 1	0.24 $\pm$ 0.12	0.26 $\pm$ 0.14	0.26 $\pm$ 0.09	0.261
Model 2	0.24 $\pm$ 0.01	0.26 $\pm$ 0.01	0.26 $\pm$ 0.02	0.587
Model 3	0.24 $\pm$ 0.02	0.26 $\pm$ 0.03	0.25 $\pm$ 0.03	0.607
BAR (% increase)				
Model 1	5.47 $\pm$ 2.98	5.79 $\pm$ 2.40	6.11 $\pm$ 2.66	0.410
Model 2	5.47 $\pm$ 0.20	5.82 $\pm$ 0.35	6.04 $\pm$ 0.49	0.571
Model 3	5.27 $\pm$ 0.50	5.59 $\pm$ 0.62	5.67 $\pm$ 0.68	0.851

Model 1: unadjusted (mean  $\pm$  standard deviation), model 2: adjusted for age (mean  $\pm$  standard error), model 3: adjusted for age, gender, race/ethnicity, hypertension, and diabetes (mean  $\pm$  standard error).

p-values were obtained from linear regression models and indicates significance (or not) for linear trends.

BAR: brachial artery reactivity, CES-D: Center for Epidemiologic Studies Depression scale.

**Table 4.** Mean values of absolute and percent increase in BAR diameter by three groups of depressive symptoms (CES-D score), stratified by smoking status; 2004-2009

	Depressive symptoms (CES-D score)			p-value
	CES-D 0-8	CES-D 9-15	CES-D ≥ 16	
Never smokers	n = 149	n = 43	n = 23	
BAR (absolute increase, mm)				
Model 1	0.23 ± 0.12	0.27 ± 0.16	0.29 ± 0.08	0.084
Model 2	0.23 ± 0.01	0.27 ± 0.02	0.29 ± 0.03	0.079
Model 3	0.20 ± 0.03	0.23 ± 0.04	0.26 ± 0.04	0.074
BAR (% increase)				
Model 1	5.20 ± 2.92	5.91 ± 3.77	6.98 ± 2.68	0.066
Model 2	5.20 ± 0.25	5.91 ± 0.47	7.01 ± 0.64	0.061
Model 3	4.39 ± 0.71	5.10 ± 0.85	5.90 ± 0.91	0.111
Former smokers	n = 53	n = 18	n = 6	
BAR (absolute increase, mm)				
Model 1	0.25 ± 0.12	0.24 ± 0.12	0.27 ± 0.09	0.983
Model 2	0.25 ± 0.02	0.24 ± 0.03	0.26 ± 0.05	0.896
Model 3	0.26 ± 0.04	0.27 ± 0.05	0.29 ± 0.07	0.856
BAR (% increase)				
Model 1	5.66 ± 3.04	5.53 ± 3.16	6.03 ± 2.00	0.850
Model 2	5.66 ± 0.41	5.66 ± 0.71	5.65 ± 1.25	0.999
Model 3	6.07 ± 0.96	6.03 ± 1.24	6.54 ± 1.62	0.890
Current smokers	n = 32	n = 14	n = 9	
BAR (absolute increase, mm)				
Model 1	0.26 ± 0.10	0.25 ± 0.10	0.17 ± 0.07	0.030*
Model 2	0.26 ± 0.02	0.25 ± 0.02	0.17 ± 0.03	0.018*
Model 3	0.29 ± 0.04	0.29 ± 0.05	0.21 ± 0.05	0.033*
BAR (% increase)				
Model 1	6.14 ± 2.94	5.73 ± 2.76	3.95 ± 1.75	0.042*
Model 2	6.20 ± 0.48	5.70 ± 0.72	3.81 ± 0.90	0.029*
Model 3	6.42 ± 1.08	6.29 ± 1.34	4.27 ± 1.43	0.040*

Model 1: unadjusted (mean ± standard deviation), model 2: adjusted for age (mean ± standard error [SE]), model 3: adjusted for age, gender, race/ethnicity, hypertension, and diabetes (mean ± SE).

p-values were obtained from linear regression models and indicates significance (or not) for linear trends.

p-values for interaction by smoking status: BAR (absolute) with CES-D score,  $p = 0.039$ ; BAR (%) with CES-D score,  $p = 0.037$ .

\* $p < 0.05$ .

BAR: brachial artery reactivity, CES-D: Center for Epidemiologic Studies Depression scale.

## Discussion

Depressive symptoms were inversely associated with brachial

reactivity yet only among officers who were current smokers and this combination may place police officers at increased risk for subclinical cardiovascular disease. While the association be-

tween smoking and cardiovascular disease is well established, the present study is among the first to explore these associations in this occupational group [35-37]. As we have previously pointed out, policing is an occupation replete with stress and traumatic events not normally experienced by the general population. Such work related stress and events are notably chronic over a national average of 20-25 years of police service [38]. Under these circumstances, associations between depression and CVD may be even more common than currently established.

The combination of depressive symptoms and smoking appeared to reveal a statistically significant inverse association with BAR in police officers. While smoking is in itself a significant risk factor for CVD, it is not possible to disentangle the causal contribution of depression and smoking to CVD due to the cross sectional study design. Some researchers report that smoking alone may increase negative affect [39]. Pizzi et al. [40] found that depressed persons were more likely to be smokers and to have impaired BAR. While smoking appears to be decreasing in the United States, a significant number of police officers continue to smoke [20,41,42]. In our present sample, 15.8% of officers were current smokers and 22.2% were former smokers.

The inverse association between depression and endothelial function has been reported in populations other than police officers. In a cohort of postmenopausal women with no known history of coronary artery disease, lifetime history of major depressive disorder (even in full remission) was associated with impaired endothelial functioning regardless of diabetes status [43]. Patients from Quebec, Canada who were diagnosed with major or minor depressive disorder had poorer endothelial function than patients without depression after risk factor adjustment and irrespective of coronary heart disease status [44]. In another cohort of patients, those who were diagnosed with significant depressive symptomatology showed poorer brachial artery FMD compared with patients who were not depressed [45].

There are important reasons for studying factors that might be associated with CVD, especially in this occupational cohort. Williams et al. [42] found that a substantial number of officers in their sample were at elevated risk for atherosclerotic heart disease; 76% had elevated cholesterol, 26% had elevated triglycerides, and 60% elevated body fat composition. Joseph et al. [46] found that police officers have increased levels of atherosclerosis compared with a general population sample, which was not fully explained by elevated CVD risk factors; thereby potentially implicating other mechanisms whereby law enforcement work may increase CVD risk. Franke et al. [20] found that public safety officers had a higher probability of de-

veloping cardiovascular heart disease than did the Framingham Heart Study population. Steinhardt et al. [47] found an inverse association between cardiovascular fitness and medical claims among police officers. Of interest is the fact that police officers either suffer from disease or die at a much earlier age than do reference groups such as municipal workers or the general United States population [2].

Some limitations of this study are possible self-selection of participants into this study, and residual confounding. It may be the case that those participants who elect to participate in research studies like this may be healthier. The potential for residual confounding can remain, even after adjustment, due to errors in covariate measurement or failure to control for the effects of other factors that were not measured in this study. The results of this study may not be generalizable to the general American population and may only be generalizable to other police officers employed in departments of similar size and location as the Buffalo Police Department. The present study is cross-sectional and causal directions involving depression, smoking, and brachial reactivity cannot be determined. Future prospective work is warranted to help clarify these associations.

This study has multiple strengths. All data collection (i.e., blood, ultrasound, physical measures) was performed at the same site, in a clinical setting, using standardized protocols and equipment, and during similar time frames. The advantages of this method are that the errors associated with assessment of many CVD risk factors are substantially reduced, since these measurements (such as blood pressure and glucose) are made by trained staff members and processed at a standardized laboratory.

As Joseph et al. [48] stated, the advantage of using sub-clinical measures is that they would apply to the broadest sample of individuals, since clinical CVD events have not already occurred in the population under study. In this way, a marker of future disease risk along with concurrent risk factors may be carefully examined. By using subclinical markers which are known to be predictive of future disease as an assessment tool, it was possible to examine levels of early atherosclerotic development in this younger population (mean age = 40.9 years) along with related risk factors.

In summary, we found that police officers exhibited increased levels of subclinical CVD in association with depressive symptoms only among those who currently smoked. Measuring early disease risk using these methods may be useful in other high-stress or emergency response occupations exposed to elevated levels of stress and trauma. Future work may help to identify additional occupational characteristics of police work that may be modifiable and serve to lower the CVD risk



in this occupation. The incorporation of wellness programs which recognize the importance of addressing modifiable risk behaviors and stress reduction are possible strategies.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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