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Abstract

Law enforcement officers suffer higher morbidity and mortality rates from all causes than the general population. Cardiovascular disease (CVD) accounts for a significant portion of the excess illness, with a reported prevalence as high as 1.7 times that of the general population. To determine which occupational hazards cause this increased risk and morbidity, it is imperative to study law enforcement officers before they retire. The long-range goal of our research is to reduce the incidence of CVD-related illness and death among aging law enforcement officers. The purpose of the present study was to measure pro- and anti-atherogenic inflammatory markers in blood samples from law enforcement officers ($n = 71$) and determine what types of occupation-related stress correlate with differences in these markers. For each outcome variable of interest, we developed separate regression models. Two groups of potential predictors were examined for inclusion in the models. Selected measures of stress were examined for inclusion in the models, in addition to general covariates, such as gender, ethnicity, years in law enforcement, and body mass index. Our results revealed statistically significant relationships between several physiologic variables and measures of stress.

Keywords

cardiovascular disease, stress

Disciplines

Cardiovascular Diseases | Kinesiology | Occupational and Environmental Health Nursing | Occupational Health and Industrial Hygiene

Comments

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Relationships Among Stress Measures, Risk Factors, and Inflammatory Biomarkers in Law Enforcement Officers

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Abstract

Law enforcement officers suffer higher morbidity and mortality rates from all causes than the general population. Cardiovascular disease (CVD) accounts for a significant portion of the excess illness, with a reported prevalence as high as 1.7 times that of the general population. To determine which occupational hazards cause this increased risk and morbidity, it is imperative to study law enforcement officers before they retire. The long-range goal of our research is to reduce the incidence of CVD-related illness and death among aging law enforcement officers. The purpose of the present study was to measure pro- and anti-atherogenic inflammatory markers in blood samples from law enforcement officers (n = 71) and determine what types of occupation-related stress correlate with differences in these markers. For each outcome variable of interest, we developed separate regression models. Two groups of potential predictors were examined for inclusion in the models. Selected measures of stress were examined for inclusion in the models, in addition to general covariates, such as gender, ethnicity, years in law enforcement, and body mass index. Our results revealed statistically significant relationships between several physiologic variables and measures of stress.

Keywords

cardiovascular disease; stress

As people age, the risk for chronic disease tends to increase; however, people become chronically ill at different ages or sometimes not at all (Newman & Ferrucci, 2009). For several decades, researchers have studied people employed in the law enforcement profession (primarily using surveillance techniques, e.g., questionnaires) to determine the incidence of cardiovascular disease (CVD) and the associated risk factors. The majority of research over the past five decades suggests that CVD is more prevalent among law enforcement officers than among the general population, especially research involving larger population cohorts (Dubrow, Burnett, Gute, & Brockert, 1988; Franke, Collins, & Hinz, 1998; Guralnick, 1962; Milham, 1983; Sardinas, Miller, & Hansen, 1986). Indeed, law enforcement officers have a higher incidence of atherosclerosis even when they are

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relatively young (Joseph et al., 2009). Among the more than 836,000 law enforcement officers in the United States (U.S. Department of Justice, 2008), the prevalence of CVD is at least as high in working officers as in the general population but as much as 1.7 times higher in retirees of this profession (Franke et al., 1998; Ramey, Downing, & Franke, 2009). This high prevalence rate has long been assumed even without empirical evidence by both many law enforcement groups and employers. For example, many states have passed heart–lung presumption laws based on the assumption that CVD-related morbidity and mortality are job related. Unfortunately, this may confound the prevalence rates for CVD in working officers because those with actual disease have retired or taken medical disability due to CVD.

The mechanism(s) underlying this increased CVD morbidity in law enforcement is unclear. It is frequently attributed to a higher exposure to CVD risk factors, such as physical inactivity, hypercholesterolemia, hypertension, tobacco use, obesity, and hyperinsulinemia (Peters, Cady, Bischoff, Bernstein, & Pike, 1983; Pollock, Gettman, & Meyer, 1978; Pyörälä, Miettinen, Laakso, & Pyörälä, 2000; Thomas, Cady, O'Connel, Bischoff, & Kershnar, 1979; Williams et al., 1987). However, traditional CVD risk factors are not the only contributors to the prevalence of CVD among law enforcement officers (Franke et al., 1998; Franke, Ramey, & Shelley, 2002).

One possible mechanism of law enforcement officers' increased risk for CVD may be work-related stress. Law enforcement is considered to be one of the most stressful occupations (National Institute for Occupational Safety and Health, 2008). In police officers, perceived stress is associated with CVD in a time-dependent manner (Ramey, Downing, & Knoblauch, 2008; Ramey, Shelley, Welk, & Franke, 2005). After controlling for age, the longer an officer is in the profession the stronger the association between perceived stress and CVD (Ramey et al., 2005, 2008).

The inflammatory response is now recognized as a key cause of CVD (Merched, Ko, Gotlinger, Serhan, & Chan, 2008; Serhan, Yacoubian, & Yang, 2008; Serhan et al., 2009). Stress may directly trigger CVD development by altering the production of several pro- and anti-atherogenic inflammatory mediators (Jain, Mills, von Kanel, Hong, & Dimsdale, 2007; Maes et al., 2002). Frequent and prolonged exposure to stress may alter the function of the immune system and lead to a proatherogenic inflammatory response (Maes et al., 2002). Stress might also indirectly contribute to CVD by affecting other CVD risk factors such as lipids, blood pressure, physical activity, and obesity (Franke et al., 2002; Ramey, 2003).

While the profession of law enforcement is considered to be a "high stress" occupation (Bureau of Labor Statistics, 2009), making it a logical population in which to study the relationship between stress and CVD risk, the extent of that relationship (and in particular, the relationship between occupational stress and risk for CVD) remains unclear. Thus, the purpose of this pilot study was to determine the association between several inflammatory markers and measures of chronic stress in a group of municipal law enforcement officers.

Working in law enforcement exposes officers to multiple types of stress, from both critical incident and organizational sources. Critical incidents include exposure to traumatic and/or violent events such as physical danger, violence, death, crime, homicides, accidents, and injury (Joseph et al., 2009). Organizational stressors are chronic and include extended work hours, shift work, a negative public image, and a governance structure that is usually hierarchical, paramilitaristic, and often involves a top-down style of management. Organizational stress can contribute to vital exhaustion, an outcome of occupational stress that has been previously associated with CVD (Appels, 1997; Appels & Mulder, 1989; Cole, Kawachi, Sesso, Paffenbarger, & Lee, 1999; Kopp, Falger, Appels, & Szedmak, 1998; Prescott et al., 2003). Other constructs associated with occupational stress include job strain, or an imbalance between job demands and job control, and effort–reward imbalance, or the feeling that the rewards of the job are insufficient relative to the effort put into the job (Appels & Mulder, 1989; Karasek, Baker, Marxer, Ahlbom, & Theorell, 1981; Peter & Siegrist, 1999; Siegrist, 1996). One negative adaptation to stress that is not within the scope of this paper is substance use, which is problematic for police officers (Cross & Ashley, 2004).

It is often assumed that critical-incident stress poses the greatest health risk to law enforcement officers; however, studies have revealed that this is not the case. In fact, the majority of occupational stress for police officers arises from within the law enforcement organization itself, with the impact of organizational stressors reportedly four to six times greater than that of critical incident stressors (Brown & Campbell, 1990; Vena, Violanti, Marshall, & Fiedler, 1986). Most previous studies, however, have conceptualized stress as unidimensional, and have not captured the cumulative effect of these multiple sources of stress. In the present study, we sought to measure the cumulative effect of multiple stressors by monitoring biological markers of stress. By quantifying and monitoring the biological effects of stress, we hope to identify relationships that precede the onset of disease, thereby enabling us to predict who is most likely to develop CVD. If we can determine which specific situations trigger heightened stress levels, then we can develop appropriate interventions that decrease risk and morbidity from CVD as well as other chronic diseases like diabetes and obesity.

Methods

Participants

A convenience sample of 71 members of the Milwaukee Police Department (MPD) participated in this study. We offered no incentive for participation, but the officers were allowed to participate while on duty. The MPD is a large metropolitan police force with more than 2,000 sworn officers stationed across Milwaukee in eight districts. The MPD and the Institutional Review Board at the University of Iowa approved this study.

Procedure

On a nonworking day or while on duty, officers came to their district headquarters to participate in this study. For each participant, the same trained, experienced member of the research team assessed height to the nearest half centimeter, weight to the nearest 0.1 kg (in light clothing and no shoes), and seated blood pressure via auscultation with a calibrated sphygmomanometer and an appropriately sized cuff. From these data, we estimated presence of overweight by using the calculated body mass index (BMI), defined as weight in kilograms divided by height in meters squared. We also drew blood via routine venipuncture for determination of inflammatory markers. We stored blood samples at −80°C for later analysis. In addition to these measures, all officers completed eight questionnaires (described below) at the time the physiologic data were collected

Physiologic Measures

Physiologic variables included several biomarkers: triglycerides, TNF-α, pro- and anti-inflammatory markers, interleukin IL-1β, IL-6, IL-4, IL-10, and the inflammatory marker C-reactive protein (CRP). We measured the levels of circulating pro- and anti-inflammatory markers and CRP by analyzing serum with high-sensitivity ELISA kits (Millipore, St. Charles, MO). The serum from 15 ml of blood was frozen at −80 °C. Briefly, serum was added to 96-well enhanced protein-binding ELISA plates precoated with the appropriate primary antibody followed by incubation and washing. The appropriate conjugated secondary antibody was added followed by another incubation period. Finally, substrate was added and absorbance at 490 nm was determined with a Bio-Rad Benchmark micro-plate reader. We determined fasting total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides using a large commercial laboratory (Quest Laboratories).

For each participant, we calculated the Framingham risk score, which estimates an individual's likelihood of having clinically significant CVD within the next 10 years. The score is based on gender, age, LDL and HDL cholesterol, blood pressure, self-reported smoking status (defined as having smoked within the past 5 years), and the presence of diabetes (self-reported on the Health Risk Survey; D'Agostino, Grundy, Sullivan, & Wilson, 2001; Wilson et al., 1998).

Finally, we measured vital exhaustion, characterized as excessive fatigue, irritability, and demoralization, using a 9-item version of Form B of the Maastricht Questionnaire (Appels, 1997; Appels & Mulder, 1988; Kopp et al., 1998). The summary scores range from 9 to 27, with higher scores representing increased feelings of vital exhaustion. Although vital exhaustion is measured with a paper-and-pencil instrument, the questions query physiologic symptoms. Therefore, we used vital exhaustion as an outcome because, in this study, we were examining stress variables as predictors of biomarkers and risk factors such as the Framingham risk score and vital exhaustion.

Psychological Measures

Officers completed a packet of questionnaires that assessed chronic stress, a number of stress constructs believed to be germane to law enforcement, as well as measures of incident stress and aggression (Table 1). Construct and content validity have been confirmed for the selected instruments. The packet of questionnaires contained the following eight instruments: the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983), Maastricht Questionnaire (Appels, 1997; Appels & Mulder, 1988; Appels & Schouten, 1991; Kopp et al. 1998), Social Provisions Scale (Cutrona & Russell, 1987), Job Content Questionnaire (Bosma et al., 1997; Karasek et al., 1998), Effort–Reward Imbalance Scale (Siegrist et al., 2004), Impact of Events Scale (Horowitz, Wilner, & Alvarez, 1979), and Aggression Questionnaire (Buss & Perry, 1992).

In addition, the packet included a Health Risk Survey consisting of 50 questions from the Behavioral Risk Factor Surveillance System (Ramey, 2003); officers completed all 50 questions on the survey. The Perceived Stress Scale, which consists of questions that focus on how unpredictable, uncontrollable, and overloaded respondents perceive their lives to have been over the past month, comprised 14 of these questions (Cohen et al., 1983). It is considered a valid and significant predictor of stress-induced consequences, including burnout, physical symptoms, and job dissatisfaction (Hills & Norvell, 1991). Perceived stress has been associated with an increased incidence of CVD among sworn, employed officers (Franke et al., 2002; Ramey, 2003). Scores range from 0 to 56, with higher scores representing higher perceived stress.

The Social Provisions Scale assesses social support, which may affect the relationship between occupation-related stress and inflammatory mediators. Indeed, previous research on police officers found that a high number of supportive persons or an increase in the social support available correlated with a decrease in perceived occupation-related stress (Graf, 1986). Scores range from 24 to 96, with higher scores indicating higher perceived support.

The Job Content Questionnaire, developed by Karasek and colleagues (1981, 1998), assesses job demand (physical and psychological) and control (decision-making latitude). Job strain occurs when the psychological and/or physical job demands (e.g., shift length and schedule) are high, yet the employee has little input into and control over the decision-making process (decision latitude) or when job demands exceed decision control. It is calculated as the ratio of job demand to job control. Scores range from 1 to 16, with higher scores indicating greater job strain.

We assessed effort–reward imbalance, which is associated with a significantly elevated risk for developing CVD, using the modified version of the Effort–Reward Imbalance Scale (Peter et al., 1998; Peter & Siegrist, 1999; Peter et al., 2002). The scale measures characteristics of job effort, such as over-commitment, competitiveness, hostility, irritability, time pressure, responsibility, and overtime. Job rewards measured include esteem of colleagues and superiors, job security, and job stability. The scale considers both personal (intrinsic) effort and situational (extrinsic) reward. The scores for the scale range from 0.25 to 4.0.

The Impact of Events Scale (Horowitz et al., 1979) examines posttraumatic stress by measuring the frequency of intrusive thoughts and avoidance of thoughts related to any traumatic events an officer experienced in the previous 7 days. Scores range from 0 to 75, with higher scores indicating greater posttraumatic stress.

We examined aggression because it is possible that individuals who choose the profession of law enforcement have similar personality traits, and the behaviors associated with anger and hostility could affect the relationships between occupation-related stress and inflammatory mediators. Men with certain personality types (e.g., aggressive) may be more likely to develop CVD (Manuck, Marsland, Kaplan, & Williams, 1995; Shekelle et al., 1985; Smith, 1992). The Aggression Questionnaire measures verbal and physical aggression, anger, and hostility. Scores range from 29 to 145, with higher scores indicating higher aggression.

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Data Analysis

We developed separate multiple regression models for each outcome variable of interest: triglycerides, Framingham risk score, TNF-α, IL-1β, IL-6, IL-4, IL-10, CRP, and vital exhaustion. The vital exhaustion score used in this study was the average of responses to the nine questions on the questionnaire. We computed the mean score for all participants based on nonmissing responses (30 participants missed 1 or 2 questions and 2 participants missed 3 questions). We examined two groups of potential predictors for inclusion in the models:

1. General covariates: race, gender, age, years in law enforcement, BMI, total cholesterol, and responses to three selected questions from the Health Risk Survey (i.e., engaged in physical activity in the past 1 month, doctor advised participant to reduce CVD risk, and took action to reduce CVD risk).
2. Psychological covariates: perceived stress, job strain, job demand, job control, effort–reward imbalance (i.e., intrinsic effort, extrinsic effort, and reward), social provision, impact events, and aggression. To avoid collinearity, we considered the covariates that represent subscales of a psychological measure and the total measure (e.g., job demand and job control are subscales of job strain) separately for inclusion in the models.

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In the first stage of the analyses, we examined bivariate relationships between each outcome and potential predictors. We also examined bivariate relationships among the psychological covariates to check for potential collinearity. We used the Wilcoxon two-sample test statistic for the dichotomous variables and the Spearman correlation coefficient for the continuous variables.

In the second stage, we applied natural log transformations to the biomarker variables (triglycerides, TNF-α, IL-1β, IL-6, IL-4, IL-10, and CRP) to improve their distributions.1

We transformed the Framingham risk score using the square-root function. Then we used multiple linear regression analysis to select variables among the general covariates for inclusion in the models. We did not enter gender, age, BMI, or total cholesterol into the model for the Framingham risk score because these variables are used to compute the Framingham risk score. We kept covariates that were statistically significant at the .05 level in the models.

Finally, we selected variables from the second group of predictors (psychological measures) using information about bivariate relationships obtained in the first stage and the least angle regression algorithm (LARS). LARS is a variable-selection algorithm that is appropriate to use when the number of variables is large relative to the sample size (Efron, Hastie, Johnstone, & Tibshirani, 2004). We also examined interactions between the psychological measures and general covariates for possible inclusion in the models. We included in the final models all general covariates selected in the second stage and all predictors and interactions that were statistically significant in the final stage ($p < .05$).

Results

Table 2 reports the demographic data for the sample. A small number of participants reported their race as "other" ($n = 4$); we grouped them with White participants for analysis purposes. Descriptive statistics appear in Table 3 for outcome variables and in Table 4 for predictor variables.

Bivariate relationships between each outcome and potential predictors appear in Table 5. An examination of the Spearman correlation coefficients among the psychological covariates revealed that, even though a number of them were statistically significant ($p < .05$), they were not high enough to cause multicollinearity; the highest coefficients were −0.50 (between reward and aggression), −0.54 (between perceived stress and social provision), and −0.61 (between intrinsic effort and reward).

We report results for the final multiple regression models in Table 6. We did not include gender in the final models because differences were not statistically significant for any of the outcomes. The models were statistically significant for triglycerides, the Framingham risk score, CRP, and vital exhaustion ($p < .0001$), and for TNF-α, IL-1β, IL-6, IL-4, and IL-10 ($p < .05$). Table 6 shows adjusted R-squared coefficients for the full models and models that include general covariates only. They demonstrate the proportion of the variance explained by adding psychological predictors and interactions to the models that already include general covariates. No psychological predictors or interactions were significant for triglycerides and CRP. For other outcomes, the additional variance explained ranged from 8% (IL-1β) to 56% (vital exhaustion).

Regression coefficients describe the strength and direction of the relationships between each covariate and the outcome variables. Most of the coefficients shown in the table were statistically significant ($p < .05$) in the final models except for coefficients for variables that we included in the models because they were part of a statistically significant interaction. In addition, we kept in the models the general covariates that were statistically significant in the second stage of model building even if they lost significance when we included the psychological covariates. We followed this procedure in order to estimate the benefit of adding psychological predictors and interactions to the models.

[1]The following transformations were used to make the distributions of biomarker data more normal: Ln (triglycerides), Ln (TNF-α + 1.5), Ln (IL-1β + 0.005), Ln (IL-6 + 1), Ln (IL-4 + 11), Ln (IL-10 + 0.5), and Ln (CRP + 1).

For outcome variables that are transformed using natural log functions, regression coefficients are interpreted in the following way: when all other predictors are held constant, a unit increase in the predictor is associated with an average increase in the outcome of 100 $[\exp(\beta)-1]$%, where β is the regression coefficient. For coefficients less than 0.1, an approximate interpretation can be used: a unit increase in the predictor is associated with an average of 100 β% increase in the outcome. Thus, a unit increase in job control and extrinsic effort were associated with an average 3% and 5% increase in TNF-α, respectively, while a unit increase in social provision was associated with an average 2% decrease in TNF-α. A unit increase in job demand was associated with an 88% increase in IL-1β. IL-6 was positively related to perceived stress and job demand, IL-4 was positively related to job demand, and IL-10 was positively related to aggression. Because we used the root square function to transform the Framingham risk score, we squared the regression coefficients when determining the magnitude of the relationships between this outcome and predictor variables. For example, a unit increase in job strain was associated with an average 0.10 increase in the Framingham risk score.

We did not transform vital exhaustion because its distribution appeared normal. Thus, we interpreted regression coefficients for vital exhaustion in a standard way; for example, for a unit increase in perceived stress, the mean for vital exhaustion increases by 0.02. Extrinsic effort and posttraumatic stress were also positively related to vital exhaustion, while job demand, reward, and social provision were negatively related.

Table 6 also reports the regression coefficients for interactions between psychological measures and two general covariates (i.e., doctor advised and action taken). These interactions were statistically significant ($p < .05$). The coefficients indicate how the association between the outcome and the psychological variable differ for the two groups: those who replied “yes” and “no” on these covariates. For example, one unit increase on the intrinsic effort score is associated with an average 32% decrease in IL-4 and one unit increase on the extrinsic effort score is associated with an average 27% increase in IL-4 for the participants who took action to reduce their risk of CVD. Those who did not take action to reduce their risk of CVD showed no such changes.

Discussion

In the current study, we explored whether, for law enforcement officers, psychological measures of stress could predict physiological outcomes. In constructing our models, we aimed to use the most specific sources of stress to precisely inform future intervention development and testing. Previous research has not taken measures of stress as predictors to the finite subscale levels used in this study. Despite the relatively small sample size in this pilot study, our results suggest that scores on several psychological measures are indeed associated with biological changes. The gender and ethnic balance of this study’s sample (reported in Table 2) was somewhat similar to the composition of MPD in its entirety: 81% males, 19% females, 80% White and other with 20% African American officers.

The patterns emerging in this study suggest interplay among physiologic markers of stress (particularly with respect to the inflammatory response) and exposure to traumatic events (measured by the Impact of Events Scale) and work-related stress. Previous studies suggest that when job demands (including exposure to traumatic events) and obligations are high but the rewards for performing the job are perceived as low (e.g., salary, esteem, and security), an imbalance can occur. Chronic exposure to these work-related stressors may thus result in changes in attitude, behavior, and lifestyle risk factors (Peter et al., 1998; Peter & Siegrist, 1999; van Vegchel, de Jonge, Bosma, & Schaufeli, 2005).

Our study found statistically significant associations between job demand and changes in several outcomes (i.e., increase in job demand was associated with increase in IL-1β, IL-4, and IL-6). For those participants who indicated that they took actions to decrease the likelihood of developing CVD (e.g., made changes in diet or exercise), these actions were associated with positive changes in their levels of IL-6.

Several variables in this study have been explored elsewhere, including perceived stress and vital exhaustion. The mean perceived stress score for our MPD sample (20.7, *SD* = 6.8) was similar to that found in a previous study of nine other Midwestern police departments (*N* = 2,818) in which the mean perceived stress score was 19.9 (*SD* = 7.3; Franke et al., 2002). For comparison, the mean perceived stress score has been reported to be as high as 31.7 in older adult widows (Ong, Bergeman, & Bisconti, 2005) and as low as 15.5 in undergraduate male nonsmokers (Croghan, Schoenbaum, Sherbourne, & Koegel, 2006).

In our study, increases in scores on the Perceived Stress Scale were associated with small increases in vital exhaustion. Outcome measures such as vital exhaustion were also correlated with events the participants experienced within the job situation. Indeed, vital exhaustion can be a consequence of stress and appears to be associated with specific types of stress, including extrinsic work effort and posttraumatic stress, as measured by the Impact of Events Scale in this study. Vital exhaustion is becoming an important outcome to consider, not only because it is an accepted risk factor for CVD (Bryant, Stevens, Truesdale, Mosley, & Chambless, 2008) but also because it has been found to predict as many as 30–60% of cardiac events (Appels, 1990; Appels & Mulder, 1988; Bryant et al.; 2008). Bryant and colleagues (2008) found that the relationship between vital exhaustion and obesity is of interest because “the disorders share similar co-morbidities” (p. 1545).

We considered vital exhaustion as an outcome rather than as a measure of stress because, conceptually, chronic exposure to stress would likely result in extreme mental and physical fatigue and irritability much like that characterized conceptually by vital exhaustion. The results of our study support this association. Officers need to be made aware of how vital exhaustion manifests itself and the possible connection between vital exhaustion and chronic diseases (both CVD and others that we did not examine in this study).

Law enforcement officers, much like other Americans, also need to be aware of the excessive prevalence of overweight and obesity in their ranks. In this study, the mean weight of officers classified them as overweight, even though 83% indicated they had been physically active in the past month. One caveat, however, is that some members of this profession have a high content of lean muscle mass, making BMI a potentially inaccurate indicator of fatness. It is within the purview of nurses to identify and test other measures of fatness. While law enforcement officers self-report being more physically active than counterparts in the general population, we need to know more about their total energy expenditure.

A better understanding of the relationships among stress, obesity, and vital exhaustion may enable us to better predict CVD. Furthermore, as abdominal fat manufactures several cytokines, occupational stress may actually contribute to the development of obesity, which in turn can increase the production of cytokines. The data from a recent, unpublished pilot study of three police departments in the Midwest support potential relationships among biomarkers of inflammation (specifically CRP) and sources of organizational stress, cortisol, eating patterns, and visceral fat. Complicating the relationship between stress and obesity are behavioral factors (e.g., sleep and physical activity) that are often adversely affected by stress and may modify or confound the relationship between stress and obesity.

Limitations

Limitations of this pilot study included the small sample size and the cross-sectional data-collection methodology. We asked the officers to fast for a 3 hr period prior to blood collection; requiring officers to fast longer than this would have constituted a burden to them because some officers were on duty. Although it has been traditional to obtain fasting lipid levels, recent studies indicate that nonfasting levels are clinically useful. In fact, in two recent studies involving large sample sizes, investigators found that nonfasting triglyceride levels are better predictors of cardiovascular events than fasting levels (Bansal et al., 2007; Nordestgaard, Benn, Schnohr, & Tybjaerg-Hansen, 2007; Ridker, 2008). In another study, researchers found small but clinically insignificant differences in fasting and nonfasting total cholesterol levels and no significant difference between fasting and nonfasting HDL levels (Craig, Amin, Russell, & Pardise, 2000). Furthermore, in one large study using the Friedewald equation, nonfasting men had lower mean LDL levels than fasting men, indicating that elevated nonfasting LDL levels are still indicative of hypercholesterolemia (Emberson, Whincup, Walker, Thomas, & Alberti, 2002).

Future studies (with larger sample sizes) should analyze psychological and biological markers longitudinally, since cross-sectional data do not provide assessment of change over time. Researchers should also consider possible mediators (i.e., emotional eating, sleep and physical activity) in future studies. Also, since we did not control for medications in this study, hypertension, hypercholesterolemia, or diabetes medications may have affected some variable values.

We used BMI as a measure of visceral adiposity. While waist circumference is more widely accepted as a measure of this variable, BMI can be a useful surrogate for measurement of body fat, especially in study populations such as ours, since it was derived from primarily White and European populations (Lear, Humphries, Kohli, & Birmingham, 2007). We recommend that any further studies consider an alternative to BMI to measure fatness, perhaps one that takes into account the high content of lean mass that can be present in law enforcement officers.

Conclusions

Understanding the effects of stress on biological outcomes empowers nurses to target interventions to promote health before pathology ensues. It is imperative to develop strategic interventions to reduce stress and risk related to the work environment in order to diminish the development of CVD and other chronic diseases in law enforcement officers and possibly other people employed in high-stress occupations. Identifying occupation-related sources of illness is a crucial step toward developing interventions that will reduce the incidence of CVD and associated risk factors.

In order to develop such interventions, we need to achieve a greater understanding of the etiology of organizational stress and the association with inflammatory markers and other biological outcomes similar to those included in this study. Because cross-sectional data do not address changes in organizational or personal stress and biomarkers over time, results of this pilot study emphasize the need for longitudinal studies with larger numbers of law enforcement officers to identify individual and aggregate patterns for these and other variables. Assumptions, including the perception that law enforcement is a sedentary profession, should be validated with physiologic evidence, such as monitoring physical activity. A clearer understanding of how the dynamic changes that happen over time are reflected in stress measures and biomarkers will likely help determine how and when to intervene to diminish the prevalence of risk and morbidity from chronic disease that occurs in this and other high-stress occupations.

Interventions will likely include changes at the systems and policy level within law enforcement agencies, as well as behavior changes addressing physical activity, healthy eating, and stress recognition and management. Other interventions might include transformational leadership principles, increased support in the form of health education for officers, clarification of job expectations, and better communication within the organization.

Employees are public servants for whom society provides salaries, pensions, and health benefits. Each officer costs departments and taxpayers approximately $93,000 per year. With approximately 17,000 criminal justice agencies in the United States employing more than 836,000 sworn officers, the cumulative costs equate to what clearly can be an exorbitant burden on already taxed local and state budgets. Therefore, it makes good economic sense to understand the health risks and needs of these officers and to keep them as healthy as possible so that they can remain in the workforce. If we can decrease the number of officers who develop CVD, the associated costs will diminish as well. Investigations into organizational sources of stress could be among the most useful since this is an area over which a department has control. The ability to identify significant biological patterns and relationships before the onset of disease will enable us to develop interventions that target specific sources of stress in particular individuals.

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Table 1

Variables and Instruments Used

Variables	Instrument	Reliability
Global stress	Perceived Stress Scale: 14-item survey (Cohen, Kamarck, & Mermelstein, 1983); answers are Likert responses.	Cronbach's α .75 (Cohen et al., 1983)
Vital exhaustion	Maastricht Questionnaire: 9-item version of Form B, including feelings of fatigue, irritability, and demoralization (Appels, 1997; Appels & Schouten, 1991; Kopp, Falger, Appels, & Szedmak, 1998); answers are Likert responses.	Cronbach's α .83 (Appels, 1997; Appels & Schouten, 1991; Kopp et al., 1998)
Social support	Social Provisions Scale: 24-item scale (Cutrona & Russell, 1987); answers are Likert responses.	Cronbach's α .85 (Cutrona & Russell, 1987)
Job demand and job control	Job Content Questionnaire: 25 items divided into four subscales: skill discretion, decision authority, social support, and job demands (Bosma et al., 1997; Karasek, Baker, Marxer, Ahlbom, & Theorell, 1981); answers are Likert responses	Cronbach's α .70–.84 (Bosma et al., 1997; Karasek et al., 1981)
Intrinsic and extrinsic reward	Effort–Reward Imbalance Scale (modified): five items measuring extrinsic effort, four items measuring intrinsic effort, and eight items related to reward and status (Siegrist et al., 2004); answers are Likert responses	Cronbach's α for the effort subscales ranges from .68 to .79 and .79 to .86 for the reward subscales (Siegrist et al., 2004)
Critical-incident stress and posttraumatic stress syndrome	Impact of Events Scale: 15 items measure response to critical incident stress after a traumatic event (Corcoran & Fischer, 1994; Horowitz, Wilner, & Alvarez, 1979)	Cronbach's α for subscales: intrusion items .78; avoidance items .82 (Corcoran & Fischer, 1994)
Aggressive behavior	Aggression Questionnaire: 29 items measure physical and verbal aggression, anger, and hostility (Buss & Perry, 1992)	Cronbach's α for subscales: physical aggression .80; verbal aggression .76; anger .72; and hostility .72 (Buss & Perry, 1992)

Table 2

Demographic and General Covariates for Participating Law Enforcement Officers (*N* = 71)

Variable	*n*	Mean ± *SD*	Range
Years in law enforcement	71	15.9 ± 5.8	4–30
Age (years)	71	42.2 ± 6.7	26–60
BMI (kg/m^2)	70	29.6 ± 4.5	18.3–42.6
Total cholesterol mg/dl	70	198.9 ± 40.2	113–317
		Percentage[a]	Coding scheme
Gender			
Male	49	75	1
Female	16	25	0
Race			
African American	14	19	1
White and other	56	80	0
Engaged in physical activity			
Yes	58	83	1
No	12	17	0
Doctor advised to reduce CVD risk			
Yes	32	45	1
No	39	55	0
Took action to reduce CVD risk			
Yes	41	59	1
No	29	41	0

Note. BMI = body mass index; CVD = cardiovascular disease.

[a]Percentages may not sum to 100 due to rounding.

Table 3

Outcome Variables (Characteristics) for Participating Law Enforcement Officers (N = 71)

Variable	*n*	Mean ± *SD*[a]	Range[a]
CVD risk factor			
Triglycerides (mg dl^{-1})	70	147.0 ± 86.1	49–569
Framingham risk score (%)	69	4.9 ± 3.3	1–14
Proatherogenic inflammatory markers			
TNF-α (pg ml^{-1})	70	4.6 ± 2.7	0.0–14.5
IL-1β (pg ml^{-1})	70	0.9 ± 1.8	0.0–9.9
IL-6 (pg ml^{-1})	70	11.8 ± 12.7	0.0–74.8
Antiatherogenic inflammatory markers			
IL-4 (pg ml^{-1})	70	97.7 ± 132.1	0.0–779.9
IL-10 (pg ml^{-1})	70	16.9 ± 35.2	0.0–196.4
Inflammatory marker			
C-reactive protein (pg ml^{-1})	68	10.0 ± 10.5	0.3–53.1
Vital exhaustion (mean score)	71	2.2 ± 0.6	1.0–3.0

Note. CVD = cardiovascular disease; IL = interleukin; TNF-α = tumor necrosis factor-α.

[a]Untransformed original values.

Table 4

Predictor Variables (Psychological Characteristics) for Participating Law Enforcement Officers (*N* = 71)

Variable(possible range of scores)	*n*	Mean ± *SD*	Range
Perceived stress (0–56)	71	20.7 ± 6.8	10–42
Job strain (1–16)	71	2.9 ± 0.5	2.0–4.6
Job demand (4–16)	71	8.7 ± 1.2	6–11
Job control (18–72)	71	55.4 ± 5.3	42.5–65.5
Effort–reward imbalance (0.25–4.0)	68	1.0 ± 0.2	0.5–1.7
Intrinsic effort (4–16)	68	9.7 ± 2.7	5–16
Extrinsic effort (5–20)	70	15.9 ± 2.5	8–20
Reward (8–32)	68	27.1 ± 3.3	16–32
Social support (24–96)	71	78.7 ± 10.1	57–93
Posttraumatic stress (0–75)	70	23.4 ± 17.0	0–61
Aggression (29–145)	71	64.6 ± 15.7	36–110

Table 5

Wilcoxon Rank Sum Test Results and Spearman Correlation Coefficients

	Outcome Variables								
Variable	**Triglycerides**	**FRS**	**TNF-α**	**IL-1β**	**IL-6**	**IL-4**	**IL-10**	**CRP**	**Mean VE**
Wilcoxon two-sample test statistic (normal approximation)									
Gender (1 = male, 0 = female)	−1.53	−3.26*	−2.29*	−0.70	−0.19	−1.17	−1.08	1.42	1.24
Race (1 = African American, 0 = White & other)	0.67	2.02*	−0.54	−0.93	−1.12	−0.78	−1.81	1.47	0.83
Physical activity (1 = yes, 0 = no)	1.06	0.44	0.18	−0.45	0.45	−0.33	−0.20	3.02*	1.42
Doctor advised (1 = yes, 0 = no)	2.42*	2.16*	1.96*	−0.07	0.89	1.74	2.13*	−0.42	1.75
Action taken (1 = yes, 0 = no)	0.70	−1.10	−1.28	0.72	−1.68	−2.36*	−1.50	1.20	1.03
Spearman correlation coefficients									
Years in law enforcement	−0.03	0.37*	0.32*	0.04	0.15	−0.01	0.21	−0.15	−0.17
BMI	0.46*	0.45*	0.14	−0.10	0.07	0.10	−0.13	0.44*	0.11
Total cholesterol	0.20	0.34*	−0.16	−0.05	0.08	0.04	0.03	0.27*	−0.14
Perceived stress	0.05	0.06	−0.02	0.12	0.32*	0.30*	0.22	0.09	0.51*
Job strain	0.10	0.20	−0.14	0.17	0.19	0.22	0.10	−0.05	0.02
Job demand	0.04	0.12	−0.03	0.27*	0.12	0.25*	0.08	−0.14	−0.11
Job control	−0.09	−0.10	0.20	0.03	−0.09	−0.07	−0.09	−0.10	−0.25*
Intrinsic effort	−0.04	−0.05	−0.13	0.09	0.30*	0.18	0.10	0.14	0.51*
Extrinsic effort	−0.13	−0.05	0.03	0.03	0.08	0.06	0.06	0.05	0.32*
Reward	−0.06	−0.08	0.10	0.04	−0.17	0.17	−0.13	0.05	−0.53*
Social support	−0.13	−0.35*	−0.16	−0.06	−0.20	−0.24*	−0.18	−0.07	−0.32*
Posttraumatic stress	0.09	0.20	0.04	−0.07	0.21	0.20	0.08	−0.03	0.47*
Aggression	0.01	0.08	0.08	0.07	0.31*	0.30*	0.20	0.02	0.42*

Note. BMI = body mass index; CRP = C-reactive protein; FRS = Framingham risk score; IL = interleukin; TNF-α = tumor necrosis factor-alpha; VE = vital exhaustion.

[*] z-scores and correlation coefficients marked with an asterisk were statistically significant ($p < .05$)

Table 6

Multiple Regression Coefficients for Covariates Associated with Each Outcome Variable

	Outcome Variables								
	Triglycerides	FRS	TNFa	IL-1β	IL-6	IL-4	IL-10	CRP	Mean VE
Intercept	2.86 ± 0.45*	1.30 ± 1.10	0.89 ± 0.88	−7.82 ± 2.13*	0.50 ± 1.18	1.17 ± 1.55	0.45 ± 0.93	−0.67 ± 0.93	4.81 ± 1.30*
General covariates									
Race (1 = African American, 0 = White & other)	–	0.40 ± 0.18*	–	–	–	–	–	–	–
Physical activity (1 = Yes, 0 = No)	–	–	–	–	–	–	–	−0.81 ± 0.28*	–
Doctor advised (1 = Yes, 0 = No)	–	−0.28 ± 0.45	−0.25 ± 1.12	–	–	–	−0.07 ± 1.32	–	−3.77 ± 1.18*
Action taken (1 = Yes, 0 = No)	–	–	–	–	−2.95 ± 1.43*	−2.64 ± 1.82	–	–	–
Years in law enforcement	–	0.03 ± 0.01*	0.01 ± 0.01	–	–	–	–	–	–
BMI	0.05 ± 0.01*	0.05 ± 0.02*	–	–	–	–	–	0.07 ± 0.02*	–
Total cholesterol	0.00 ± 0.00*	–	–	–	–	–	–	0.01 ± 0.00*	–
Psychological covariates									
Perceived stress	–	−0.03 ± 0.01*	–	–	0.04 ± 0.02*	–	−0.03 ± 0.03	–	0.02 ± 0.01*
Job strain	–	0.31 ± 0.13*	–	–	–	–	–	–	–
Job demand	–	–	–	0.63 ± 0.24*	0.18 ± 0.09*	0.26 ± 0.11*	–	–	−0.11 ± 0.04*
\Job control	–	–	0.03 ± 0.01*	–	–	–	–	–	–
Intrinsic effort	–	–	–	–	–	0.16 ± 0.08	–	–	–
Extrinsic effort	–	–	0.05 ± 0.02*	–	−0.07 ± 0.06	−0.10 ± 0.07	–	–	0.06 ± 0.02*
Reward	–	–	–	–	–	–	–	–	−0.06 ± 0.02*
Social support	–	−0.02 ± 0.01*	−0.02 ± 0.01*	–	–	–	–	–	−0.02 ± 0.01*
Posttraumatic stress	–	0.02 ± 0.01*	–	–	–	–	–	–	0.01 ± 0.00*
Aggression	–	–	–	–	–	0.00 ± 0.01	0.03 ± 0.01*	–	−0.00 ± 0.01
Interactions									
Perceived stress × doctor advised	–	0.05 ± 0.02*	–	–	–	–	0.16 ± 0.05*	–	–

	Outcome Variables								
	Triglycerides	FRS	TNFa	IL-1β	IL-6	IL-4	IL-10	CRP	Mean VE
Intrinsic effort × action taken	–	–	–	–	–	−0.28 ± 0.11*	–	–	–
Extrinsic effort × doctor advised	–	–	−0.09 ± 0.04*	–	–	–	–	–	–
Extrinsic effort × action taken	–	–	–	–	0.21 ± 0.09*	0.24 ± 0.10*	–	–	–
Social support × doctor advised	–	–	0.02 ± 0.01*	–	–	–	–	–	0.04 ± 0.01*
Posttraumatic stress × doctor advised	–	−0.03 ± 0.01*	–	–	–	–	–	–	–
Aggression × doctor advised	–	–	–	–	–	–	−0.04 ± 0.02*	–	0.01 ± 0.01*
Aggression × action taken	–	–	–	–	–	0.04 ± 0.02*	–	–	–
Adjusted R-squared (full model)	0.22	0.52	0.23	0.08	0.19	0.30	0.17	0.28	0.59
Adjusted R-squared (general covariates only)	0.22	0.31	0.08	0.00	0.03	0.07	0.04	0.28	0.03

Note. BMI = body mass index; CRP = C-reactive protein; FRS = Framingham risk score; IL = interleukin; TNF-α = tumor necrosis factor-alpha; VE = vital exhaustion.

*Regression coefficients marked with an asterisk were statistically significant ($p < .05$).