OREGON HEALTH & SCIENCE UNIVERSITY
SCHOOL OF MEDICINE

ASSOCIATION OF LOW PHYSICAL ACTIVITY WITH METABOLIC SYNDROME IN LAW ENFORCEMENT OFFICERS

By
Bharti Garg

A THESIS

Presented to the Department of Public Health & Preventive Medicine
and the Oregon Health & Science University
School of Medicine
in partial fulfillment of
the requirements for the degree of
Master of Public Health
July 2013

School of Medicine
Oregon Health & Science University

CERTIFICATE OF APPROVAL

This is to certify that the Master's thesis of

Bharti Garg

has been approved

William Lambert, PhD, Advisor
OHSU Department of Public Health and Preventive Medicine

Thuan Nguyen, MD, PhD
OHSU Department of Public Health and Preventive Medicine

Kerry Kuehl, MD, DrPH
OHSU Department of Medicine

Diane Elliot, MD
OHSU Department of Medicine

TABLE OF CONTENTS

Page

TABLES

Page

FIGURES

Page

ACKNOWLEDGEMENTS

There are several people to thank who have been instrumental in the completion of this project. Foremost, I would like to thank Dr. Kerry Kuehl and Dr. Diane Elliot, without whom this project would have been impossible. I am really grateful for their guidance and insight. My advisor and Committee members have always been available and provided me support and encouragement and more importantly, have been very patient with me during this process. I am also grateful to my thesis advisor, Dr. William Lambert for his guidance and support. His expertise has helped me improve my writing skills and helped me prepare for future challenges. I am also thankful to my biostatistician, Dr. Thuan Nguyen for always being there to help me during the analysis. She was a great help during this project. I would also like to acknowledge research staff of Health Promotion and Sports Medicine Department who collected the data for this project. Thanks to my parents for their love, and for instilling value on higher education. Special thanks to my husband, Rajeev, for his consistent support, understanding, and love over the years. And a very big thanks to my daughter, Isha, who always put a smile on my face and let me work on the project.

SHIELD study is supported by NIOSH (National Institute of Occupational Safety and Health) grant (5RO10H0009676-03).

ABSTRACT

Background: Law enforcement officers (LEOs) have a high prevalence of metabolic syndrome, as defined by the clinical signs of increased waist circumference, elevated blood pressure and triglycerides, decreased HDL cholesterol and increased fasting glucose. The factors leading to this syndrome are not well understood.

Objective: To test the association between physical activity and metabolic syndrome among LEO's.

Methods: Physical measures (height/weight, blood pressure), blood biomarkers (triglycerides, HDL cholesterol, and glucose), self-reported physical activity, and stress were obtained from 309 police officers (242 males and 67 females) at entry into a randomized controlled trial. The presence of metabolic syndrome was classified according to NCEP/ATP III guidelines. Logistic regression was used to test the association between physical activity and metabolic syndrome, adjusted for potential confounders.

Results: Among the participants, 34.3% had metabolic syndrome. The presence of metabolic syndrome was inversely associated with self-reported physical activity ($r = -0.26$, $p < 0.0001$). After controlling for age, gender, race, sleep, healthy eating, smoking and alcohol consumption, the odds of metabolic syndrome in low physically active LEOs was 3.05 (95% CI: 1.62, 5.76; $p = 0.001$) times that in high physically active LEOs.

Conclusion: The strong association of physical activity with risk of metabolic syndrome suggests that this modifiable risk factor can be targeted to prevent metabolic syndrome and its co-morbidities among law enforcement professionals.

CHAPTER 1

INTRODUCTION

Metabolic syndrome consists of multiple, interrelated elements that result in the development of atherosclerotic cardiovascular disease (Grundy, 2005). Metabolic syndrome is defined as the presence of any three of the following five conditions: increased waist circumference (abdominal obesity); elevated triglycerides; decreased HDL cholesterol; elevated blood pressure; and elevated plasma glucose (Grundy, 2005). The presence of metabolic syndrome is recognized as a strong predictor of coronary heart disease, stroke, and Type 2 diabetes mellitus (Wannamethee, 2005).

Some studies indicate that law enforcement officers (LEOs) have a higher prevalence of metabolic syndrome than the general population (Chandramohan, 2008; Tharkar, 2008); while others indicate that LEOs have a similar or lower prevalence (Thompson, 2003). Tharkar et al. (2008) found that prevalence of metabolic syndrome among male police officers (n=318) was significantly higher (57.3 vs. 28.2%, =64.5, $p<0.0001$) than their age-matched general male population (n=401) ($p<0.0001$). Alternatively, Violanti (2009) found that approximately 16% of 101 LEOs (61 males and 40 females) were defined as having metabolic syndrome. The age-adjusted prevalence of the metabolic syndrome among US adult men was 23.7% in the period 1988 to 1994 (Ford, 2002), and this rate subsequently increased to approximately 34% in 1999 to 2002 (Ford, 2005).

Physical activity and metabolic syndrome

Regular physical activity can reduce the clinical signs of metabolic syndrome, such as body weight and visceral fat, blood pressure, HDL and triglycerides (Katzmarzyk, 2003). LEOs, as an occupational group, exhibit lack of physical activity when compared to the general population (Tharkar, 2008). In one study of LEOs which examined the combined influence of physical activity and stress on metabolic syndrome, it was also found that regardless of stress levels, low (< 30minutes of physical activity of any kind per week) and moderate (≥ 30 minutes to 60 minutes of physical activity of any kind per week) levels of physical activity were associated with two- and three-fold higher odds for having metabolic syndrome than high levels of physical activity (> 60 minutes of vigorous physical activity) (Yoo, 2009). This suggests that physical inactivity is an important risk factor for metabolic syndrome among LEOs.

Stress and metabolic syndrome

It has been well documented that stress is an important risk factor for metabolic syndrome (Edwards, 2012). Perceived stress has been linked with cardiovascular disease as well as components of metabolic syndrome (Zimmerman, 2012). As an occupation, police work is highly demanding and stressful (Gershon, 2002). In the Whitehall II study (Chandola, 2006), employees with chronic stress (three or more exposures) were more than twice as likely have metabolic syndrome than those without work stress (OR adjusted for age and employment grade=2.25). In female police officers, Hartley (2011) found that job stress is significantly associated with metabolic syndrome and its components.

Sleep and metabolic syndrome

Previous research has shown that among law enforcement professionals, lack of sleep (McCanlies, 2012) is an important risk factor for metabolic syndrome. Sleep deprivation and sleep disorders are common in police officers. The most common sleep disorder is obstructive sleep apnea; in one study by Rajaratnam and colleagues (2011), more than one-third were affected.

Shift work and metabolic syndrome

It has been well documented that atypical work hours are strongly associated with risk of metabolic syndrome (Violanti, 2009). Odds for metabolic syndrome for subjects who work 7 - 8 hours /day is 2.32 (95% CI: 1.04-5.16) times as compared to who work 10 -12 hours /day (Kobayashi, 2012). In addition to metabolic syndrome, shift work is also associated with the components of metabolic syndrome. Di Lorenzo et al. (2003) suggested that non-day shift workers have higher BMI and higher SBP levels than day workers.

Metabolic syndrome is a major public health issue and has been identified as a risk factor for cardiovascular disease (Salazar, 2013). Physical activity has been shown to positively affect each of the metabolic syndrome elements (Leon, 2001; Fagard, 2001) and is a modifiable behavior. In law enforcement officers, physical activity during active duty police work is usually limited and insufficient to maintain physical fitness (Richmond, 1998). It is important, therefore, to quantify the association between physical activity and metabolic syndrome in this population, in order to improve our understanding of the potential for physical activity interventions to protect this at-risk occupational group. The purpose of our study is to determine the prevalence of metabolic syndrome in police officers, and to identify potential risk factors, specifically of the role of physical activity. We hypothesize that there is a significant association between low physical activity and metabolic syndrome after controlling confounders.

CHAPTER 2

MATERIAL AND METHODS

Study Design, subjects and data collection

This analysis uses a cross-sectional design to investigate the potential association of low physical activity with metabolic syndrome in law enforcement officers. We used baseline data from the SHIELD (Safety and Health Improvement: Enhancing Law Enforcement Department) study, collected by the Health Promotion and Sports Medicine Division at Oregon Health & Science University.

Three-hundred nine law enforcement officers in two county sheriff offices and one police department participated (enrollment rate = 43.8%). All of the subjects were sworn LEOs employed on patrol, investigational or other enforcement duties. A liaison officer at each site facilitated recruitment, scheduling and communication. Research staff traveled to each agency for questionnaire administration. In addition to survey data collection, physical and laboratory measures were obtained, including: resting blood pressure, anthropometric indices (e.g., height, weight, waist circumference, and neck circumference) and blood work (e.g., serum total cholesterol, triglycerides, HDL [high density lipoproteins], LDL [low density lipoproteins] and glucose) (Bucolo, 1973; Friedewald, 1972).

The protocol was approved by the Oregon Health & Science University Institutional Review Board (IRB00006309).

Instrument

The self-report survey assessed demographics, physical activity, dietary behavior, and stress. Most response fields were 7-point Likert-type scales, anchored by “strongly agree" and "strongly disagree" labels. The instrument included measures previously established as reliable, and additional constructs devised in the research group's previous studies (MacKinnon, 2010).

The reliability of the survey instrument as applied in law enforcement officers was assessed using the constructs from the previous PHLAME study on firefighters (“Promoting Healthy Lifestyles: Alternative Model Effects”) (MacKinnon, 2010). Specifically, Cronbach’s alpha was used to assess the internal reliability of multi-item constructs for physical activity (alpha=0.89), stress (alpha=0.80), healthy eating (alpha= 0.82), alcohol consumption (alpha= 0.79), and sleep habits (alpha =0.86). The high reliability observed in our sample of LEOs was consistent with the instrument’s performance of firefighters in PHLAME (Elliot, 2007).

Variable description

Metabolic Syndrome (Outcome)

Data were analyzed to examine the prevalence of metabolic syndrome and its components. The selected measures of metabolic syndrome were based on the National Cholesterol Education Program Adult Treatment Panel III guidelines with modifications from the American Heart Association and the National Heart, Lung and Blood Institute (Grundy, 2005). There are five components of metabolic syndrome, and for the purposes of this analysis, the presence of any three of the five criteria listed below, was used to classify the presence of metabolic syndrome.

- **Elevated waist circumference:** ≥ 102cm (≥ 40 inches) in men and ≥ 88cm (≥ 35 inches) in women

- **Elevated triglycerides:** ≥ 150 mg/dl (≥ 1.7 mmol) OR drug treatment for elevated triglycerides

- **Reduced HDL:** < 40mg/dl (1.03 mmol/L) in men and < 50 mg/dl (1.3 mmol/L) in women OR drug treatment for reduced HDL

- **Elevated blood pressure:** ≥ 130 mm of Hg systolic blood pressure OR ≥ 85 mm of Hg diastolic blood pressure OR drug treatment for hypertension

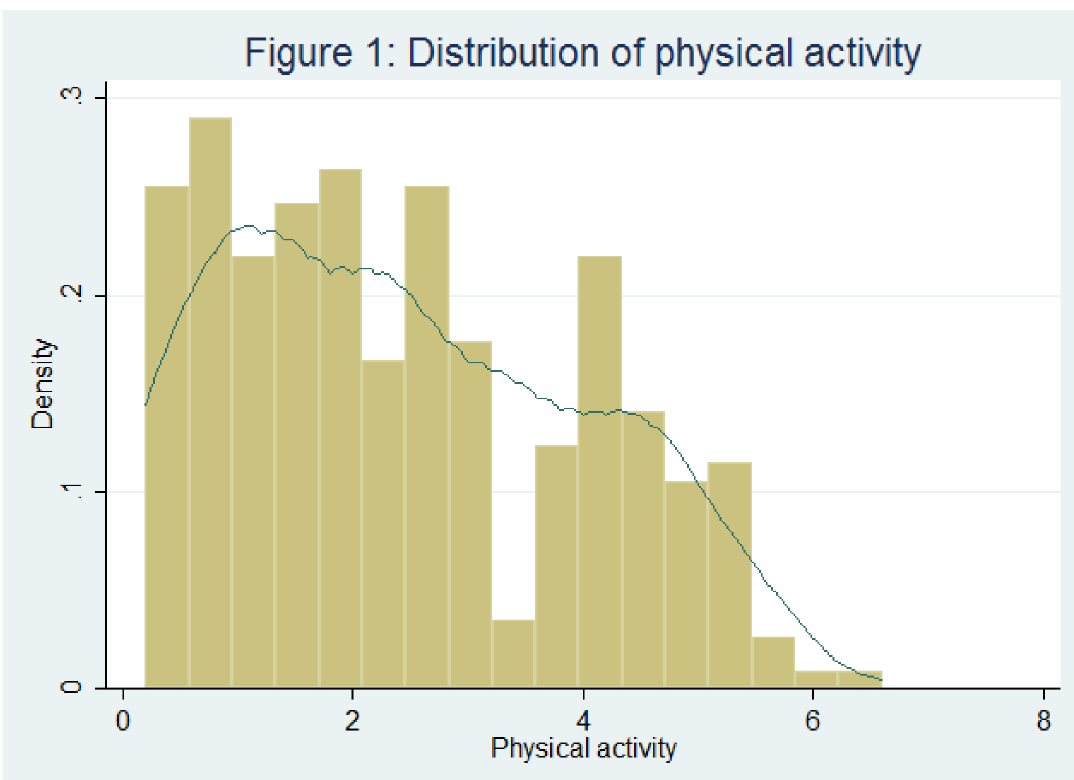
- **Elevated fasting glucose:** ≥ 100mg/dl OR drug treatment for elevated glucose

In the anthropometric assessment, waist circumference was measured in centimeters as abdominal girth at the highest point of the iliac crest and the lowest part of the costal margin in the mid-axillary line. Resting systolic and diastolic blood pressures were measured in a seated position using standard mercury sphygmomanometer and auscultatory methods. The average of the second and third of three resting systolic and diastolic blood pressure readings were used. Levels of triglycerides, HDL and glucose were measured from fasting blood specimens (Bucolo, 1973, Friedewald, 1972).

Physical Activity (primary predictor)

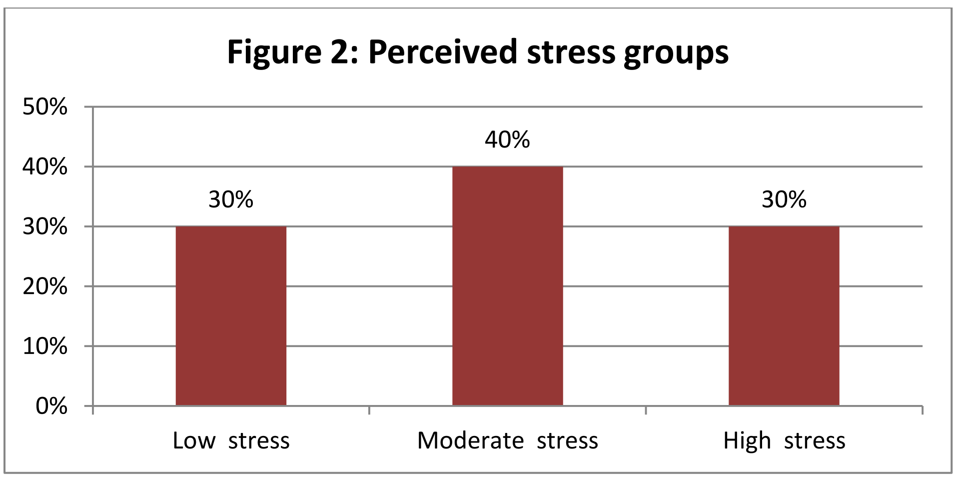
The construct "physical activity" is a composite score by taking average of five items which include: “days/week of hard physical activities that make you sweat and breathe hard for at least 30 minutes”, “days/week of moderate physical activities that increased your breathing for a total of at least 30 minutes during the day”, “days/week of strengthening or toning of muscles, such as push-ups, sit-ups or weight lifting”, and “days/week of any physical activity long enough to work up a sweat”, “I exercise for 30 minutes almost every day” (Mathews, 1999).

The physical activity construct displayed a bimodal distribution (shown in Figure 1) and was dichotomized into low physically active LEOs, and high physically active LEOs, using the cut-off of 3 to classify low (62.5%, N=193)vs. high (37.5%, N=116) groups.



Stress (covariate)

Stress was assessed by four items regarding job stress (Jordon, 2002; Violanti, 2009; McCreary, 2006), which include: "I feel significant stress at work", "worrying about work issues makes it hard to relax at home", "overall I feel like there is too much stress in my job", and "in general I manage stress in a healthy way" (reverse coded). Stress was divided into three groups as low perceived stress (0.5 SD below the mean perceived stress), moderate perceived stress (± 0.5 from the mean perceived stress) and high perceived stress (0.5 SD above the mean perceived stress). It was found that 30% of the LEOs had low perceived stress, 40% had moderate perceived stress and 30% of LEOs had high perceived stress.



Alcohol Use (covariate)

Alcohol consumption was assessed using six questions which include: "how frequently do you have at least one alcoholic drink in the past 30 days", "how frequently do you have several drinks in one sitting in the past 30 days", "how frequently do you drink to the point of getting buzzed in the past 30 days", "how frequently do you drink to the point of getting drunk in the past 30 days", "how often during the last 30 days have you had feelings of guilt or remorse after drinking", and "my family or friends have been concerned about my drinking in the last 6 months".

Alcohol consumption was treated as a continuous variable.

Healthy Eating (covariate)

Healthy eating was analyzed by five items which include: "on average how often do you eat fast food", "I make healthy choices when ordering fast food", "I select healthy food items when eating at restaurants", "in general I eat five or more servings of fruits and vegetables per day", and "in general I eat a low-fat diet".

Healthy eating was treated as continuous variable.

Sleep deficiency (covariate)

Sleep habits were assessed by using similar items as used by Division of Sleep Medicine at Brigham & Women's Hospital for their study of police officers and the Pittsburgh Sleep Quality Index (Buysse, 1989). The items include: "in the past 7 days, I was satisfied with my sleep" (reverse coded), "I don't usually get enough time between work shifts to recover my energy fully", "in the past 7 days my sleep quality was" (reverse coded), "in the past 7 days, how often have you had trouble sleeping", "physically I feel exhausted today", "I have plenty of reserve energy when I need it" (reverse coded), "in the past 7 days, how often have you gotten enough sleep" (reverse coded), "in the past 7 days, I had a hard time getting things done because I was sleepy", and "in the past month how many hours of sleep did you average in a 24 hr period" (reverse coded).

Sleep deficiency was treated as a continuous variable.

Other covariates

The other covariates were shift work (dichotomized into day-shift and non-day shift), smoking status (dichotomized to smokers and non-smokers), race (dichotomized to white and non-white), gender (males and females) and age (continuous variable).

Statistical methods

All statistical analyses were performed using STATA IC 12. Descriptive statistics were used to characterize the sample. For the LEOs with and without metabolic syndrome, descriptive statistics for gender, race, education and position of the LEOs were calculated. The prevalence of metabolic syndrome (and its components) was assessed, and the most common three components of metabolic syndrome were analyzed. Following assessment of prevalence, the differences between high and low physically active LEOs was analyzed to examine whether there was any statistical difference between the two groups. The differences among LEOs with and without metabolic syndrome were also analyzed to determine if there is any statistical difference among those two groups. Continuous variables were examined with t-tests and categorical variables were examined with chi-square tests. Logistic regression was then performed with metabolic syndrome as the dichotomous outcome variable. First, simple logistic regression was performed using physical activity as the primary predictor and crude odds ratio, 95% confidence interval and *p*-value was estimated. Then, the potential interaction between physical activity and stress was tested to see if the association between physical activity and metabolic syndrome differed by level of stress. Similarly, another interaction between physical activity and sleep was tested to see if the association between physical activity and metabolic syndrome differed by level of sleep. If the interaction terms were not significant, the variables of stress and sleep were evaluated as confounders.

Covariates were evaluated for potential confounding using the conventional approach. First, the variable needed to be associated with both physical activity and metabolic syndrome. Then, crude and adjusted odds ratios were examined; a variable that altered the crude odds ratio by at least 10% in bivariable analysis was considered a potential confounder in the construction of the multivariate model.

We used the Hosmer-Lemeshow goodness-of-fit statistic to evaluate alternative models comprised of varying sets of covariates, specifically the inclusion of variables for sleep and healthy eating.

CHAPTER 3

RESULTS

Demographic Characteristics

The demographic variables of the sample of LEOs are summarized in Table 1. The mean age of the law enforcement officers was 42.0 years (SD=8.8). Eighty-five percent were male, the majority (93.2%) of the sample were of white or Caucasian race. The average BMI of the male and female LEOs was 29.7 and 28.6 respectively, approximately the same as the national age-adjusted average BMI of 28.7 in males and 28.7 in females reported by Flegal et al. (2012).

Table 1: Demographic characteristics of law enforcement officers.

Characteristic	Metabolic Syndrome (N, percentage)	No Metabolic Syndrome (N, percentage)
Gender		
Women	16 (15%)	51 (25%)
Men	90 (85%)	152 (75%)
Race		
White	95 (92%)	188 (93%)
Black	1 (1%)	4 (2%)
Asian	4 (4%)	0 (0%)
Pacific Islander	1(1%)	2 (1%)
American Indian	1 (1%)	0 (0%)
Other	1 (1%)	7 (4%)
Position		
Enforcement	48 (46 %)	116 (57 %)
Custody/Institutions	33 (31 %)	50 (25 %)
Administration	12 (11 %)	20 (10 %)
Other	13 (12 %)	17 (8 %)
Education		
High School	11 (11 %)	13 (6 %)
Some College	57 (55 %)	91 (45 %)
College graduate	35 (34 %)	98 (49 %)

Out of 309 LEOs, 164 (53%) worked in enforcement, 83 (27%) worked in custody/institutions, 32 (10%) worked in administration, and 30 (10%) worked in parole & probation. Most of the law enforcement officers were well educated, reporting some college (48%) or being a college graduate (43%).

Prevalence of Metabolic Syndrome

One hundred six (34.3%) of the law enforcement officers in our sample had physiologic measurements consistent with metabolic syndrome. The prevalence of metabolic syndrome and its components are presented in Table 2. The most prevalent individual component was elevated blood pressure (49.8%), followed by elevated triglycerides (45.9%) and reduced HDL cholesterol (34.9%). The most common combination of components was central obesity, high triglycerides and hypertension (N=50, 16.2%).

Table 2: Prevalence of Metabolic Syndrome and Its Components		
Syndrome Component	n	%
Elevated waist circumference (>40inches in men, >35 inches in women)	99	32.1
Elevated triglycerides (>150mg/dl)	142	45.9
Reduced HDL cholesterol (<40mg/dl in men, <50mg/dl in women)	108	34.9
Glucose intolerance (fasting glucose>100mg/dl)	97	31.4
Hypertension (BP>130/85mm of Hg)	154	49.8
Metabolic Syndrome		
0 component	54	17.5
1 component	81	26.2
2 components	68	22.0
≥ 3 components	106	34.3

The prevalence of metabolic syndrome in low physically active LEOs was 43%, whereas high physically active group had a prevalence of 20% (Figure 3). There was a statistically significant relationship between physical activity and metabolic syndrome (= 17.3, $p < 0.001$).

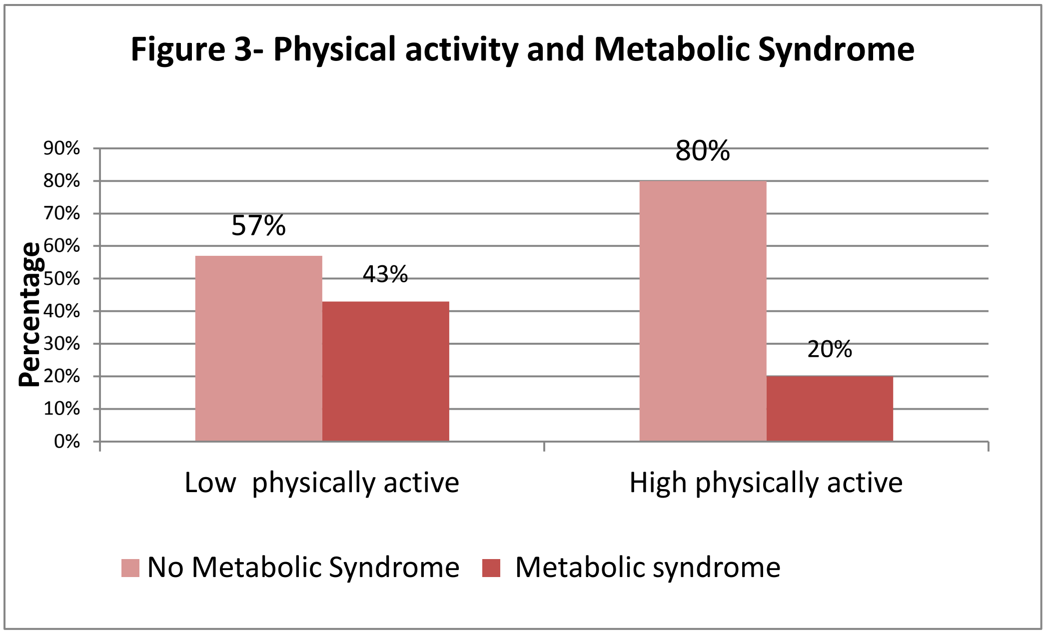


Figure 3- Physical activity and Metabolic Syndrome

Table 3 compares the metabolic syndrome components among low and high physically active LEOs. The percentages of all of the individual components of metabolic syndrome were higher in the low physically active LEOs. Although the mean BMI was comparable in two groups (30.4 ± 5.4 vs. 28.8 ± 4.8 kg /), abdominal obesity was significantly more prevalent among less active LEOs. In the low physically active group, 15.6% were smokers, while in high physically active group, 10.7% LEOs were smokers.

Table 3: Metabolic syndrome components among low and high physically active law enforcement officers.				
Variable	Low Physically active (N=193)	High Physically active (N=116)		*p*-value
Central obesity (cm)	74 (38.3%)	25(21.5%)	9.38	0.002
Elevated triglycerides (mg/dl)	97 (50.3%)	45(38.8%)	3.8	0.05
Reduced HDL cholesterol (mmoL/L)	80 (41.4%)	28 (24.1%)	9.5	0.002
High glucose (mg/dl)	61 (31.6%)	36 (31.1%)	0.01	0.91
Hypertension (mm of Hg)	106 (54.9%)	48 (41.4%)	5.3	0.02

Table 4 compares LEOs with and without metabolic syndrome. As expected, average BMI was significantly higher in the LEOs with metabolic syndrome (32.8 vs. 27.7, , as was the proportion of those classified with a low level of physical activity (78.3% vs. 54.2%,

Table4: Differences among LEOs with and without metabolic syndrome.

Variable	No metabolic syndrome (N=203)	Metabolic syndrome (N=106)	*p*-value
Age (Mean years ± SD)	40.5 ± 7.9	44.8 ± 9.8	<0.001
Gender			
• Males	152 (74.8%)	90 (84.9%)	0.042
• Females	51 (25.2%)	16 (15.1%)	
BMI (kg /)	27.7 ± 3.5	32.8 ± 5.5	<0.001
Smoker	28 (13.8%)	14 (13.7%)	0.97
Physical activity			
• Low	110 (54.2%)	83 (78.3%)	<0.001
• High	93 (45.8%)	23 (21.7%)	
Alcohol	1.0 ± 0.8	0.8 ± 0.7	0.01
Healthy Eating	4.2 ± 1.2	3.8 ± 1.2	0.01
Sleep deficiency	3.2 ± 0.9	3.3 ± 1.0	0.45
Stress			
• Low	67 (33%)	28 (26%)	
• Moderate	90 (44%)	32 (31%)	0.001
• High	46 (23%)	46 (43%)	

Logistic Regression

The crude odds ratio showed that the odds of metabolic syndrome in less physically active LEOs is 3.05 times the odds of metabolic syndrome in high physically active LEOs (95% CI: 1.8 to 5.2; $p < 0.001$). When interaction terms were tested for the covariates stress and sleep, we found that neither was statistically significant (stress $p = 0.17$ and sleep $p = 0.26$). The covariates race, sleep deficiency, healthy eating, alcohol intake and smoking status were identified as potential confounders, as the change in crude odds ratio was greater than 10% in the bivariate analysis. Age and gender were preselected as confounders from the review of literature (Cho 2009, Kim 2013). As presented in Table 5, the final model contained physical activity, age, gender, race, alcohol, smoking status, sleep deficiency and healthy eating.

After adjusting for age, gender, race, sleep deficiency, healthy eating, smoking and alcohol status, the odds of metabolic syndrome in less physically active LEOs was 3.05 times the odds of metabolic syndrome in high physically active LEOs. (95% CI: 1.6 to 5.8, $p = 0.001$).

Table 5: Crude and Adjusted Estimates				
Variable	Crude OR	95% CI		*p*-value
Physical activity (0=High PA, 1=Low PA)	3.05	1.78	5.22	< 0.001
Variable	Adjusted OR	95% CI		*p*-value
Physical activity	3.05	1.84	6.05	0.001
Age	1.05	1.03	1.09	< 0.001
Gender (0 = Males, 1 = Females)	0.37	0.18	0.77	0.008
Smoker (0=Non-smokers, 1=Smokers)	1.05	0.46	2.22	0.97
Race (0=Non-white, 1=White)	0.99	0.35	2.77	0.99
Alcohol	0.67	0.47	0.97	0.034
Healthy Eating	0.89	0.70	1.12	0.32
Sleep deficiency	1.12	0.85	1.48	0.41
Intercept	0.11	0.01	0.68	0.018

The Hosmer-Lemeshow goodness-of-fit test was not significant, indicating that this model provides an acceptable fit ($p = 0.45$).

CHAPTER 4

DISCUSSION

Although reviews of literature suggest that physical inactivity has an important role in affecting the risk of metabolic syndrome in adults of the general population (Cho, 2009), our study is the first to examine this relationship in law enforcement officers, a large occupational group with unique demographic characteristics and job activities.

Our findings are consistent with the previous findings of Lakka and colleagues (2003) that physical inactivity is a strong risk factor for metabolic syndrome. Our analysis demonstrated that low physical activity is significantly associated with metabolic syndrome adjusting for the potential confounders of age, gender, race, sleep deficiency, healthy eating, smoking status and alcohol consumption (OR = 3.05, $p = 0.001$). These results suggest that low physically active LEOs have a significantly higher risk of metabolic syndrome as compared to high physically active LEOs.

Although the variable stress was not significant and therefore did not enter the multivariate logistic regression model as a confounder in the forward stepwise method, nor as an interaction term, it was highly associated with metabolic syndrome. As shown in Figure 4, the prevalence of metabolic syndrome monotonically increases with increasing levels of stress at in the LEOs with low physical activity, whereas the prevalence of metabolic syndrome steadily decreases in the high physical activity group.

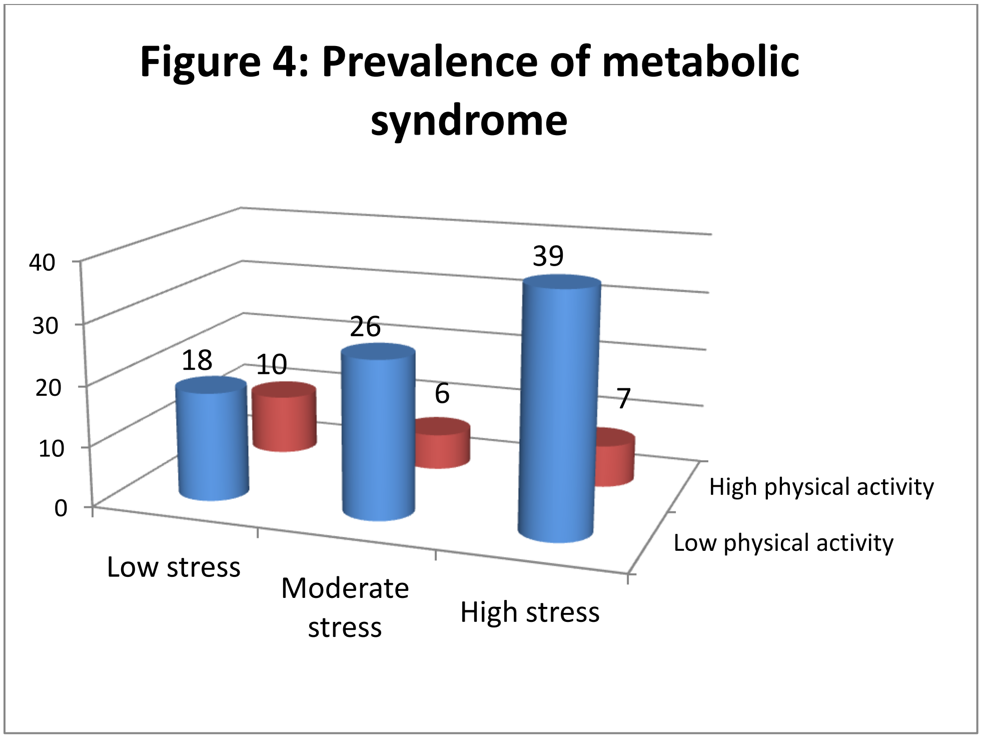
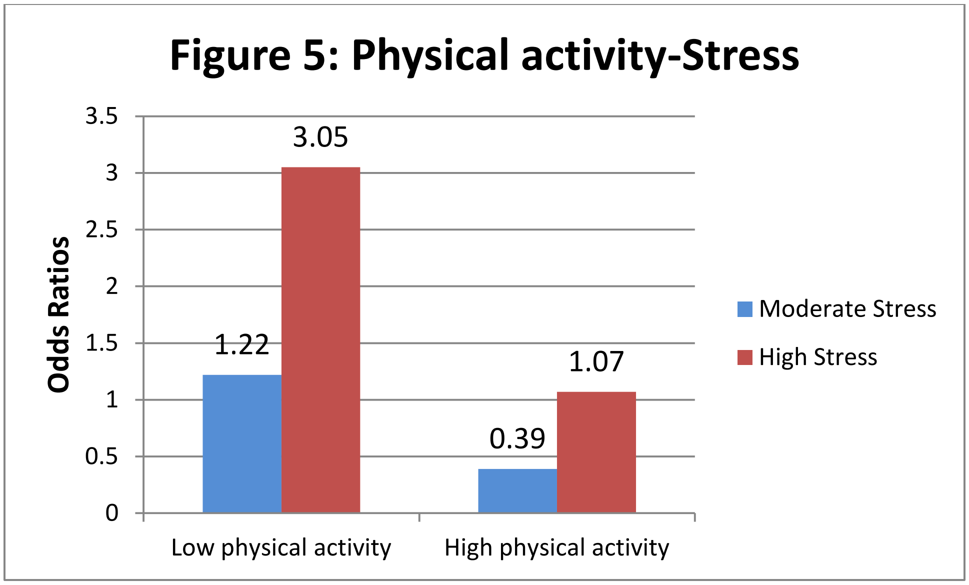


Figure 5 presents the odds ratios for stress and metabolic syndrome at low and high levels of physical activity. In the low physical activity level, stress had statistically significant association with the presence of metabolic syndrome; the odds of metabolic syndrome in moderate stressed LEOs was 1.22 (95% CI: 0.58, 2.55; $p = 0.59$) times the odds of metabolic syndrome in low stressed LEOs, while among high stressed LEOs the odds were 3.05 (95% CI: 1.45, 6.42; $p = 0.003$) times that of low stressed LEOs. Whereas among high physically active LEOs, stress was not statistically associated with metabolic syndrome; the OR among moderately stressed LEOs was 0.38 (95% CI: 0.13, 1.17; $p = 0.09$) times the odds of metabolic syndrome in low stressed LEOs, while the odds in high stressed LEOs was 1.07 (95% CI: 0.34, 3.29; $p = 0.91$) times the odds of metabolic syndrome in low stressed LEOs. Although our analysis focused on the examination of the role of physical activity in the risk of metabolic syndrome, our findings suggest that physical activity may act as a mediator of stress.



These findings suggest that physical activity is a protective resource factor against metabolic syndrome for LEOs under stress. Future studies are needed to further explore the role of stress in the etiology of metabolic syndrome, and stress should not be overlooked while designing prevention and treatment programs to reduce the risk of metabolic syndrome in LEOs.

The prevalence of metabolic syndrome in our study is comparable to that reported for the general US population. Recently, Ervin and colleagues (2009) found that 34% of adults met the criteria of metabolic syndrome in a sample of 3423 adults aged ≥ 20 years from NHANES 2003-2006 using the definition of the National Cholesterol Education Program. All studies among LEOs previous to ours estimated the prevalence of metabolic syndrome to be lower than the general population (McCanlies, 2012). Violanti (2009) found that 16.3% police officers had metabolic syndrome and Yoo (2009) reported that 23.1% LEOs possessed metabolic syndrome.

The prevalence of metabolic syndrome in the population is increasing and reaching epidemic proportions, and is likely to lead to future increases in cardiovascular diseases and premature mortality. It has been found that inflammation and oxidative stress, physiologic states that are both associated with obesity, play crucial roles in patho-physiology of the metabolic syndrome (Wellen, 2005). While the nature of the mechanism is not precisely understood, there is evidence for dysregulation of the feedback mechanism between IL-6 and noradrenalin which can contribute to the systemic low-grade inflammation and hyperglycemia observed in metabolic syndrome (Martin-Cordero, 2011). Physical activity controls the release and activity of two cytokines: IL-6 (anti-inflammatory cytokine) and TNF-α. IL-6 is the first cytokine to be released in the circulation during exercise, and its levels increase in an exponential fashion in response to exercise (Erdei, 2007). When secreted by T-cells and macrophages, IL-6 stimulates the immune response and boosts inflammatory reactions, while muscle produced IL-6 exerts anti-inflammatory effects through its inhibitory effects on TNF-α, IL-1β and activation of interleukin-1 receptor antagonist and IL-10 (Febbraio, 2005). These feedback mechanisms suggest that increased physical activity can have beneficial effects in the physiologic pathways of metabolic syndrome.

Our findings are consistent with the previous studies that regular physical activity can affect metabolic syndrome risk through its effect on the factors used to define the syndrome, such as reducing waist circumference, visceral fat, subcutaneous fat, and enhancing insulin sensitivity (Ross, 2000), reducing blood lipids (Leon, 2001) and blood pressure (Fagard, 2001). Yoo (2009) demonstrated that high physically active LEOs had lower BMI, triglycerides, and higher HDL cholesterol as compared to moderate or low physically active LEOs. We observed similar differences in our study; the high physically active LEOs had lower average BMI, triglycerides, blood pressure, glucose and high HDL as compared to less physically active group.

We also observed a significantly elevated prevalence of abdominal obesity in our low physically active LEOs (77.8%) compared to high physically active group (22.2%). This is a great concern, as abdominal obesity is a well-established indicator of future health problems (Violanti, 2011), specifically among police officers, where increased risk of type 2 diabetes and cardiovascular disease has been demonstrated (Reijo, 2012).

The limitations of this study warrant discussion. First, it is difficult to establish causal relationship from observational data collected in a cross-sectional time frame. We cannot establish the temporal sequence between physical activity and metabolic syndrome. Secondly, there is the potential problem of prevalence-incidence bias. In our cross-sectional design, we measured prevalence not incidence, and our sample may over represent cases of long duration. Furthermore, there is a potential for recall bias in the assessment of physical activity and the other behaviors measured, although minimized through the use of standardized and validated questionnaires. Additionally, some aspects of variable definition and operationalization of our model should be considered. Our cut-off for classifying high vs. low levels of physical activity was empirically determined, and therefore as a relative measure derived from our sample of LEOs, may not be valid to apply in other study groups. Also, the variables alcohol, sleep deficiency, and healthy eating were treated as continuous variables rather than categorical variables, which may limit the interpretability and utility of the model.

CHAPTER 5

SUMMARY AND CONCLUSION

This study demonstrates that low physical activity is significantly associated with metabolic syndrome in law enforcement professionals. Not only the risk of metabolic syndrome, but the proportion of the individual components of metabolic syndrome is higher in LEOs with low physical activity, which suggests that increasing levels of physical activity may be protective. Physical activity is an important etiological factor in the metabolic syndrome (Nguyen, 2012) and the sedentary behavior associated with driving and desk-work in law enforcement may increase risk in this occupational group. The major implication of this study is that wellness programs tailored for LEOs which promote increased levels physical activity (Elliot 2013, Kuehl 2013) may help to decrease the risk of metabolic syndrome . Additional research is needed to examine these associations prospectively, in larger cohorts from multiple regions of the US and to replicate these findings in more diverse LEO populations, including different racial and ethnic backgrounds.

REFERENCES

Bucolo, G., David, H. (1973). Quantitative determination of serum triglycerides by the use of enzymes. *Clinical Chemistry*, 19(5), 476-482.

Buysse, DJ., Reynolds, CF., Monk, TH., Berman, SR., Kupfer, DJ. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research*, 28, 193-218.

Chandola, T., Brunner, E., Marmot, M. (2006). Chronic stress at work and the metabolic syndrome: Prospective study. *British Medical Journal, 332*(7540), 521-525.

Chandramohan, P., Mohan, V. (2008). High prevalence of diabetes and metabolic syndrome among policemen. *Journal of the Association of Physicians of India, 56*, 837-839.

Cho, E. R., Shin, A., Kim, J., Jee, S. H., Sung, J. (2009). Leisure-time physical activity is associated with a reduced risk for metabolic syndrome. *Annals of Epidemiology, 19*(11), 784-792.

Di Lorenzo, L., De Pergola, G., Zocchetti, C., L'Abbate, N., Basso, A., Pannacciulli, N., Cignarelli, M., Giorgino, R., Soleo, L. (2003). Effect of shift work on body mass index: Results of a study performed in 319 glucose-tolerant men working in a Southern Italian industry. *International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity, 27*(11), 1353-1358.

Edwards, E. M., Stuver, S. O., Heeren, T. C., Fredman, L. (2012). Job strain and incident metabolic syndrome over 5 years of follow-up: The coronary artery risk development in young adults study. *Journal of Occupational & Environmental Medicine, 54*(12), 1447-1452.

Elliot, D. L., Kuehl, K., Garg, B., Lund, J., Kuehl, H., DeFrancesco, C., McGinnis, W., Sleigh, A., Smith, J., O'Rourke, H., MacKinnon, D. (2013). Why are women police officers more burned-out and what would help them? *Annals of Behavioral Medicine*, 45:s220.

Elliot, D. L., Goldberg, L., Kuehl, K. S., Moe, E. L., Breger, R. K., Pickering, M. A. (2007). The PHLAME (promoting healthy lifestyles: Alternative models effects) firefighter study: Outcomes of two models of behavior change. *Journal of Occupational & Environmental Medicine, 49*(2), 204-213.

Erdei, N., Bagi, Z., Edes, I., Kaley, G., Koller, A. (2007). H2O2 increases production of constrictor prostaglandins in smooth muscle leading to enhanced arteriolar tone in type 2 diabetic mice. *American Journal of Physiology - Heart & Circulatory Physiology, 292*(1), H649-56.

Ervin, R. B. (2009). Prevalence of metabolic syndrome among adults 20 years of age and over, by sex, age, race and ethnicity, and body mass index: United states, 2003-2006. *National Health Statistics Reports*, (13), 1-7.

Fagard, R. H. (2001). Exercise characteristics and the blood pressure response to dynamic physical training. *Medicine & Science in Sports & Exercise, 33*(6), S484-92.

Febbraio, M. A., Pedersen, B. K. (2005). Contraction-induced myokine production and release: Is skeletal muscle an endocrine organ? *Exercise & Sport Sciences Reviews, 33*(3), 114-119.

Flegal, K. M., Carroll, M. D., Kit, B. K., Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Journal of the American Medical Association, 307*(5), 491-497.

Ford, E. S., Giles, W. H., Dietz, W. H. (2002). Prevalence of the metabolic syndrome among US adults: Findings from the third national health and nutrition examination survey. *Journal of the American Medical Association, 287*(3), 356-359.

Ford, E. S., Kohl III, H. W., Mokdad, A. H., Ajani, U. A. (2005). Sedentary behavior, physical activity, and the metabolic syndrome among U.S. adults. *Obesity Research, 13*(3), 608-614.

Friedewald, W. T., Levy, R. I., Fredrickson, D. S. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry,* 18(6), 499-502.

Gershon, R. R. M., Lin, S., Li, X. (2002). Work stress in aging police officers. *Journal of Occupational and Environmental Medicine, 44*(2), 160-167.

Grundy, S. M., Cleeman, J. I., Daniels, S. R., Donato, K. A., Eckel, R. H., Franklin, B. A., Costa, F. (2005). Diagnosis and management of the metabolic syndrome: An American heart Association/National heart, lung, and blood institute scientific statement. executive summary. *Cardiology in Review, 13*(6), 322-327.

Hartley, T. A., Burchfiel, C. M., Fekedulegn, D., Andrew, M. E., Knox, S. S., Violanti, J. M. (2011). Associations between police officer stress and the metabolic syndrome. *International Journal of Emergency Mental Health, 13*(4), 243-256.

Hartley, T. A., Knox, S. S., Fekedulegn, D., Barbosa-Leiker, C., Violanti, J. M., Andrew, M. E., Burchfiel, C. M. (2012). Association between depressive symptoms and metabolic syndrome in police officers: Results from two cross-sectional studies. *Journal of Environmental & Public Health,* 861219.

Jordon, M. H., Feild, H. S., Armenakis, A. A., (2002). The relationship of group process variables and team performance. *Small Group Research*;33(1):121-150.

Katzmarzyk, P. T., Leon, A. S., Wilmore, J. H., Skinner, J. S., Rao, D. C., Rankinen, T., Bouchard, C. (2003). Targeting the metabolic syndrome with exercise: Evidence from the HERITAGE family study. *Medicine and Science in Sports and Exercise, 35*(10), 1703-1709.

Kim, J., Tanabe, K., Yokoyama, N., Zempo, H., & Kuno, S. (2013). Objectively measured light-intensity lifestyle activity and sedentary time are independently associated with metabolic syndrome: A cross-sectional study of Japanese adults. *International*

Journal of Behavioral Nutrition & Physical Activity, 10, 30. doi:http://dx.doi.org.liboff.ohsu.edu/10.1186/1479-5868-10-30

Kobayashi, T., Suzuki, E., Takao, S., Doi, H. (2012). Long working hours and metabolic syndrome among Japanese men: A cross-sectional study. *Biomed central Public Health, 12,* 395.

Kuehl, K., Elliot, D. L., MacKinnon, D., Smith, J., Kuehl, H. (2013). Are law enforcement officers fit for duty? *Annals of Behavioral Medicine* , 45, s287.

Lakka, T. A., Laaksonen, D. E., Lakka, H. M., Mannikko, N., Niskanen, L. K., Rauramaa, R., Salonen, J. T. (2003). Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Medicine & Science in Sports & Exercise, 35*(8), 1279-1286.

Leon, A. S., Sanchez, O. A. (2001). Response of blood lipids to exercise training alone or combined with dietary intervention. *Medicine & Science in Sports & Exercise, 33*(6 Suppl), S502-15.

MacKinnon, D. P., Elliot, D. L., Thoemmes, F., Kuehl, K. S., Moe, E. L., Goldberg, L., Ranby, K. W. (2010). Long-term effects of a worksite health promotion program for firefighters. *American Journal of Health Behavior, 34*(6), 695-706.

Martin-Cordero, L., Garcia, J. J., Hinchado, M. D., Ortega, E. (2011). The interleukin-6 and noradrenaline mediated inflammation-stress feedback mechanism is dysregulated in metabolic syndrome: Effect of exercise. *Cardiovascular Diabetology, 10*, 42.

Matthews, C. E., Heil, D. P., Freedson, P. S., Pastides, H. (1999). Classification of cardiorespiratory fitness without exercise testing. *Medicine & Science in Sports and Exercise*, 31, 486-493.

McCanlies, E. C., Slaven, J. E., Smith, L. M., Andrew, M. E., Charles, L. E., Burchfiel, C. M., Violanti, J. M. (2012). Metabolic syndrome and sleep duration in police officers. *Work, 43*(2), 133-139.

McCreary, D.R., Thompson, M. M. (2006). Development of two reliable and valid measures of stressors in policing. *International J Stress Management* ;13, 494-518

Nguyen, T. H., Tang, H. K., Kelly, P., Vanderploeg, H. P., Dibley, M. J. (2010). Association between physical activity and metabolic syndrome: A cross sectional survey in adolescents in Ho Chi Minh City, Vietnam. *Biomed central Public Health, 10*, 141.

Peterson, K. E., Hebert, J. R., Hurley, T. G., Resnicow, K., Thompson, F. E., Greene, G. W., Nebeling, L. (2008). Accuracy and precision of two short screeners to assess change in fruit and vegetable consumption among diverse populations participating in health promotion intervention trials. *Journal of Nutrition, 138*(1), 218S-225S. Retrieved from

Rajaratnam, S. M., Barger, L. K., Lockley, S. W., Shea, S. A., Wang, W., Landrigan, C. P., O'Brien, C. S., Qadri, S., Sullivan, J. P., Cade, B. E., Epstein, L. J., White, D. P., Czeisler, C. A. (2011). Sleep disorders, health, and safety in police officers. *Journal of American Medical Association, 306*(23), 2567-2578.

Rennie, K. L., McCarthy, N., Yazdgerdi, S., Marmot, M., Brunner, E. (2003). Association of the metabolic syndrome with both vigorous and moderate physical activity. *International Journal of Epidemiology, 32*(4), 600-606.

Richmond, R. L., Wodak, A., Kehoe, L., Heather, N. (1998). How healthy are the police? A survey of life-style factors. *Addiction*, *93*(11), 1729-1737.

Ross, R., Dagnone, D., Jones, P. J., Smith, H., Paddags, A., Hudson, R., Janssen, I. (2000). Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. *Annals of Internal Medicine, 133*(2), 92-103

Salazar, M. R., Carbajal, H. A., Espeche, W. G., Aizpurua, M., Leiva Sisnieguez, C. E., March, C. E., Reaven, G. M. (2013). Identifying cardiovascular disease risk and outcome: Use of the plasma triglyceride/high-density lipoprotein cholesterol concentration ratio versus metabolic syndrome criteria. *Journal of Internal Medicine*, *273*(6), 595-601.

Siren, R., Eriksson, J. G., Vanhanen, H. (2012). Waist circumference a good indicator of future risk for type 2 diabetes and cardiovascular disease. *Biomed Central Public Health, 12*, 631.

Tharkar, S., Kumpatla, S., Muthukumaran, P., Viswanathan, V. (2008). High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *Journal of the Association of Physicians of India, 56*, 845-849.

Thompson, P. D., Buchner, D., Piña, I. L., Balady, G. J., Williams, M. A., Marcus, B. H., Wenger, N. K. (2003). Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: A statement from the council on clinical cardiology (subcommittee on exercise, rehabilitation, and prevention) and the council on nutrition, physical activity, and metabolism (subcommittee on physical activity). *Circulation, 107*(24), 3109-3116. doi:10.1161/01.CIR.0000075572.40158.77

Violanti, J. (1999). Police trauma: psychological trauma of civilian combat. Police trauma: psychological aftermath of civilian combat. *Springfield, IL: Charles C. Thomas*, pp. 5-9.

Violanti, J. M., Fekedulegn, D., Hartley, T. A., Andrew, M. E., Charles, L. E., Mnatsakanova, A., Burchfiel, C. M. (2006). Police trauma and cardiovascular disease: Association between PTSD symptoms and metabolic syndrome. *International Journal of Emergency Mental Health, 8*(4), 227-237.

Violanti, J. M., Burchfiel, C. M., Hartley, T. A., Mnatsakanova, A., Fekedulegn, D., Andrew, M. E., Vila, B. J. (2009). Atypical work hours and metabolic syndrome among police officers. *Archives of Environmental & Occupational Health, 64*(3), 194-201.

Violanti, J. M., Fekedulegn, D., Andrew, M. E., Charles, L. E., Hartley, T. A., & Burchfiel, C. M. (2011). Adiposity in policing: Mental health consequences. *International Journal of Emergency Mental Health, 13*(4), 257-266.

Wannamethee, S. G., Shaper, A. G., Lennon, L., & Morris, R. W. (2005). Metabolic syndrome vs Framingham risk score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Archives of Internal Medicine, 165*(22), 2644-2650. doi:10.1001/archinte.165.22.2644.

Wellen, K. E., Hotamisligil, G. S. (2005). Inflammation, stress, and diabetes. *Journal of Clinical Investigation, 115*(5), 1111-1119.

Yoo, H. L., Eisenmann, J. C., & Franke, W. D. (2009). Independent and combined influence of physical activity and perceived stress on the metabolic syndrome in male law enforcement officers. *Journal of Occupational and Environmental Medicine, 51*(1), 46-53. doi:10.1097/JOM.0b013e31817f9e43.

Zimmerman, F. H. (2012). Cardiovascular disease and risk factors in law enforcement personnel: A comprehensive review. *Cardiology in Review, 20*(4), 159-166.