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Nicole C. Koebke
University of Kentucky, nkoebke31@gmail.com

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Nicole C. Koebke, Student

Dr. Mark Abel, Major Professor

Dr. Richard Riggs, Director of Graduate Studies

PHYSICAL ACTIVITY, SLEEP PATTERNS, AND HEALTH OUTCOMES
IN UNIVERSITY LAW ENFORCEMENT OFFICERS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Education
at the University of Kentucky

By

Nicole C. Koebke

Lexington, Kentucky

Director: Dr. Abel, Associate Professor of Kinesiology and Health Promotion

Lexington, Kentucky

2012

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ABSTRACT OF THESIS

PHYSICAL ACTIVITY, SLEEP PATTERNS, AND HEALTH OUTCOMES IN UNIVERSITY LAW ENFORCEMENT OFFICERS

Research indicates that law enforcement officers (LEOs) have a higher prevalence of developing coronary artery disease (CAD) compared to the general population. Sleep deprivation and physical inactivity have been found to be related to many risk factors for CAD. This cross-sectional study examined the health status and the relationship between sleep and physical activity outcomes versus CAD risk factors among 27 University LEOs. The subjects' health behaviors, and CAD and metabolic syndrome risk factors were described using basic statistics. Accelerometer derived sleep and physical activity outcomes were correlated to measures of health to identify potential relationships. 33% of LEOs were classified as moderate risk for CAD; 92% had dyslipidemia, 58% had elevated triglycerides, 23% had prediabetes, and 22% suffered from obesity. The administrators and first shift LEOs slept more compared to second or third shift LEOs. The LEOs were more sedentary while on-duty. In addition, sedentary time was correlated to systolic blood pressure. LEOs accumulated $24.4 \text{ min}\cdot\text{d}^{-1}$ of moderate-to-vigorous physical activity (MVPA), but only spent $9.3 \text{ min}\cdot\text{d}^{-1}$ in continuous bouts of MVPA. In conclusion, multiple CAD risk factors were present in these LEOs and achieving adequate amounts of physical activity and sleep may decrease their risk of developing chronic diseases.

KEYWORDS: Police Officers, Coronary Artery Disease, Metabolic Syndrome, Physical Activity, Sleep

Nicole C. Koebke

July 30, 2012

PHYSICAL ACTIVITY, SLEEP PATTERNS, AND HEALTH OUTCOMES IN
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By

Nicole C. Koebke

Dr. Mark Abel

Director of Thesis

Dr. Richard Riggs

Director of Graduate Studies

August 6, 2012

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my advisor and thesis director, Dr. Mark Abel, for all of the invaluable guidance, support, and direction he has given me the past two years. This thesis would not have been possible without him. I would like to thank the rest of my committee, Dr. J.W. Yates and Dr. Jody Clasey, for their insight and support during this process. I am also truly indebted and thankful for Liz Easley. Without her knowledge, encouragement, and flexibility, data collection would not have been possible. I would like to extend a very special thank you to my parents, Cindy and Bob Koebke, for their unconditional love, support, and understanding. I would also like to thank my research partner-in-crime, Annie Beck, and T.J. Giganti for their confidence and encouraging words, I couldn't have done this without either of you. Last, but not least, I would like to thank all of the participants of my study (who remain anonymous for confidentiality purposes) for making my research possible.

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Chapter I

Introduction

Maintaining optimal levels of health is critical for law enforcement officers (LEOs). Some research indicates that LEOs have a higher prevalence of developing coronary artery disease (CAD), metabolic syndrome, and obesity compared to the general population (Franke et al., 1998). Other research has found that LEOs have a similar prevalence of CAD compared to the general population, but differences in the prevalence of major CAD risk factors (Franke et al., 2002). Reports suggest that heart attacks are responsible for 22% of fatalities among on-duty LEOs (USFA-FEMA, 2002). These fatalities have been associated with an increased prevalence of CAD risk factors such as physical inactivity, hypertension, dyslipidemia, and obesity (Franke et al., 2002; Franke et al., 2010). There are several health behaviors that may impact the risk of developing these chronic diseases, including sleep patterns and physical inactivity.

Research indicates that sleep deprivation is related to an increased risk of developing CAD and metabolic syndrome among shift workers (Violanti et al., 2009). Specifically, sleep deprivation has been found to be directly related to an increased waist circumference, increased body mass index (BMI) and percent body fat, high insulin and glucose levels, and insulin resistance; all of which are factors related to CAD and the metabolic syndrome (Violanti et al., 2009). Additionally, sleep debt may negatively affect carbohydrate metabolism and endocrine function, therefore contributing to the metabolic syndrome (Violanti et al., 2009). A study conducted by Violanti et al. (2009) evaluated self-reported sleep duration and found that LEOs who worked the midnight

shifts were at an increased risk for metabolic syndrome, most likely due to sleep deprivation caused by a difficulty of sleeping during the day.

Although law enforcement can be a demanding and dangerous occupation, it is primarily a sedentary occupation with only occasional periods of physical activity. These periods of physical activity are insufficient to maintain fitness levels necessary for LEOs to effectively perform their job duties (Boyce et al., 2008). Even though performing vigorous physical tasks may be a rare occurrence during a typical shift, LEOs must be prepared for situations that require a high degree of physical exertion (Adams et al., 2010; Boyce et al., 2008). Tasks such as chasing subjects on foot, climbing fences and stairs, overcoming barriers, using firearms, restraining suspects, and rescuing victims require LEOs to possess a certain amount of endurance and strength (Adams et al., 2010; Boyce et al., 2008). Thus, maintaining adequate physical activity levels may decrease a LEO's risk of chronic disease and provide some level of requisite physical fitness to perform essential job tasks. A study conducted by Pollock, Gettman and Meyer (1978) found that middle-aged LEOs had below-average fitness levels and a greater CAD risk when compared to the average sedentary population of similar age. Additionally, physically active LEOs have lower absenteeism rates than their sedentary counterparts (Steinhardt, Greenhow, & Stewart, 1991).

Physical health status is affected by numerous modifiable and non-modifiable health factors. However, it is important to identify the primary modifiable behaviors that negatively affect the health status of LEOs, such as sleep and physical activity. There is some existing research on the sleep patterns and physical activity levels of LEOs (Steinhardt et al., 1991; Violanti et al., 2009). However, these investigations have relied

on subjective self-reported measures of sleep and physical activity outcomes. Although these investigations provide valuable information, they possess an inherent level of bias based on the participants' subjective reports of sleep and physical activity. Using objective measurements of these outcomes to accurately quantify these health behaviors and evaluate their relationship with chronic disease risk factors could add to our understanding of the relationships. Furthermore, there is a lack of research on health outcomes of University LEOs. Therefore, the purpose of this study was to (i) examine the health status of University LEOs, and (ii) to determine the relationship between sleep and physical activity outcomes versus CAD and metabolic syndrome risk factors among LEOs. We hypothesized that unhealthy sleep habits and low physical activity levels will be related to a variety of CAD and metabolic syndrome risk factors in LEOs.

Delimitations

This study was delimited to the following:

1. Male and female University LEOs between the ages of 24 to 55 years.
2. The University LEOs were located in Lexington, KY.

Assumptions

This study had the following assumptions:

1. It was assumed that LEOs provided honest responses on the health history questionnaire.
2. It was assumed that the LEOs wore the sleep monitors and physical activity monitors themselves.

Chapter II

Review of the Literature

Introduction

Cardiovascular diseases are a leading cause of mortality and morbidity in the United States (Roger et al., 2010). Coronary artery disease (CAD), a type of cardiovascular disease, caused approximately 1 of every 6 deaths in the United States in 2007 (Roger et al., 2007). Risk factors established by the American College of Sports Medicine as being associated with CAD include the following: age, family history, cigarette smoking, physical inactivity, obesity, hypertension, dyslipidemia, and prediabetes (ACSM, 2010c). Metabolic syndrome is characterized by the clustering of certain CAD risk factors (ACSM, 2010a). These risk factors, as established by the National Cholesterol Education Program as being associated with the metabolic syndrome, include the following: abdominal obesity, elevated triglycerides, low HDL cholesterol, elevated blood pressure, and elevated fasting blood glucose (National Cholesterol Education Program, 2002). In the United States, the metabolic syndrome affects approximately 34% of adults (Roger et al., 2010; Yoo, Eisenmann, & Franke, 2009). The etiology of CAD and the metabolic syndrome is multi-faceted and can include an unhealthy diet, physical inactivity, genetics, and obesity (Yoo, Eisenmann, & Franke, 2009).

Law enforcement officers (LEOs) are not immune to developing CAD or the metabolic syndrome. In fact, some research indicates that LEOs have a higher prevalence of developing CAD, metabolic syndrome, and obesity compared to the general population (Franke et al., 1998). Multiple studies have found that employment as a LEO

is associated with an increased CAD morbidity and mortality (Franke, Collins, & Hinz, 1998; Violanti, Vena, & Petrali, 1998). Additionally, another study found that 23% of LEOs were classified as having the metabolic syndrome (Yoo, Eisenmann, & Franke, 2009). Other research found that LEOs have a similar prevalence of CAD compared to the general population, but differences in the prevalence of major CAD risk factors (Franke et al., 2002). Reports suggest that heart attacks are responsible for 22% of fatalities among on-duty LEOs (USFA-FEMA, 2002). These fatalities have been associated with an increased prevalence of CAD risk factors such as physical inactivity, hypertension, dyslipidemia, and obesity (Franke et al., 2002; Franke et al., 2010).

There are several health behaviors that may impact the risk of developing these chronic diseases, including sleep patterns and physical activity. Research indicates that sleep deprivation is related to an increased risk of developing CAD and metabolic syndrome among shift workers (Violanti et al., 2009). Specifically, sleep deprivation has been found to be directly related to an increased waist circumference, increased body mass index (BMI) and percent body fat, high insulin and glucose levels, and insulin resistance; all of which are factors related to CAD and the metabolic syndrome (Violanti et al., 2009). Additionally, although law enforcement can be a demanding and dangerous occupation, it is primarily a sedentary occupation with only occasional periods of physical activity which are insufficient to maintain fitness levels (Boyce et al., 2008). Maintaining adequate physical activity levels may decrease a LEO's risk of chronic disease and provide some level of requisite physical fitness to perform essential job tasks. Thus, the purpose of this literature review is to discuss the impact of physical activity and sleep patterns with CAD and the metabolic syndrome in LEOs.

Physical activity, law enforcement and CAD risk factors

During the past couple of decades, research has become increasingly clear that several CAD risk factors are associated with physical activity levels in the general population (Sassen et al., 2010). Specifically, leading a sedentary lifestyle may increase an individual's risk for developing obesity, hypertension, dyslipidemia, and prediabetes (Laaksonen et al., 2002, Lakka et al., 2003, Sassen et al., 2010). The research has shown that regular physical activity increases a person's cardiorespiratory fitness and provides benefits for each individual CAD risk factor, resulting in an overall preventative effect on CAD morbidity and mortality (Sassen et al., 2010). Additionally, increased physical activity levels have also been found to positively influence interrelated risk factors for CAD (abdominal obesity, high blood pressure, high triglycerides, high blood glucose, and low LDL cholesterol), also known as the metabolic syndrome (Lakka et al., 2003, Rennie et al., 2003, Sassen et al., 2010).

A higher level of either physical activity plays an important role in reducing the CAD mortality (Franke & Anderson, 1994). Exercise has been found to decrease LDL cholesterol, triglyceride levels, and glucose intolerance as well as increase HDL cholesterol, improve insulin sensitivity, and improve rate-pressure product (Franke & Anderson, 1994; Yoo, Eisenmann, & Franke, 2009). Furthermore, elevated levels of physical activity may lower elevated plasma catecholamine levels, decreasing blood pressure, and produce decreases in body weight, waist circumference, and accumulations of visceral and subcutaneous fat (Blair, Jacobs, & Powell, 1985). Previous studies have found associations between habitual activity and body fatness, as well as associations between exercise habits and body mass index (Blair, Jacobs, & Powell, 1985).

A meta-analysis performed by Cornelissen and Fagard (2005) examined the effect of chronic aerobic endurance training on blood pressure, blood-pressure regulating mechanisms, and other cardiovascular disease risk factors. They concluded that physical activity does decrease both systolic and diastolic blood pressure, most notably in those individuals who are already hypertensive, in addition to decreasing body weight, waist circumference, percent body fat, insulin resistance, and increasing HDL cholesterol (Cornelissen & Fagard, 2005).

Physical activity, both during leisure time and in the workplace, has been shown to reduce the risk of developing CAD risk factors and to reduce CAD-related events and mortality (Williams et al., 1987). The literature shows that law enforcement officers are not immune to developing CAD; in fact, they may be at a greater risk due to inadequate levels of physical activity while on the job. Samford, Weltman, Moffat, and Fulco (1978) assessed physical fitness status among members of the Louisville Police Department and found that the older LEOs had lower levels of cardio-respiratory fitness and increased body weight and body fat compared to the younger LEOs. Additionally, when they looked at the effects of 4 months of vigorous physical training, they found significant increases in VO_{2max} and decreases in body fat; however, after 1 year of active duty (during which physical activity was limited to job requirements only), they found that cardio-respiratory fitness and body fat returned to the pre-training levels (Samford et al., 1978).

Williams et al. (1987) assessed 171 male police officers for CAD risk factors and evaluated the relationship of fitness to risk. The high fitness group (defined as having the greatest mean treadmill exercise capacity and the greatest mean number of self-reported

physical activity sessions per week) had considerably lower levels of CAD risk factors (Williams et al., 1987). Specifically, the high fitness group was found to have considerably lower body fat, diastolic blood pressure, total cholesterol, LDL cholesterol, lipid ratios, triglyceride level, and smoking incidence compared to the moderate and low fitness groups. The results of this study suggests that the severity of certain CAD risk factors can be decreased with an increase in exercise capacity and leisure time physical activity in LEOs (Williams et al., 1987).

A study done in 1994 by Franke and Anderson looked at the relationship between physical fitness measures, exercise habits, and 10-year CAD risk among 470 LEOs. They found that, much like the general population, LEO's have an increased risk for developing CAD as they get older, and this risk was greater in physically inactive LEOs older than 48 years compared to their physically active counterparts. The exercising LEOs were found to have an improved TC:HDL ratio and the LEOs greater than 36 years old were found to have a significantly higher body fat percentage than LEOs younger than 36 years regardless of exercise habits (Franke & Anderson, 1994).

More recently, a cross-sectional study was done by Sassen et al. (2009) assessing the effects of different levels of physical activity on CAD and metabolic syndrome risk factors on 1298 healthy police officers in Utrecht, Netherlands. They found significant inverse relationships between self-reported physical activity level, physical fitness and clustering of metabolic syndrome risk factors (Sassen et al., 2009). The fittest LEO's were reported to have an 87% lower risk of developing metabolic syndrome compared to the inactive LEOs. Additionally, it was found that the more time the LEO spent participating in moderate intensity physical activity, the lower their waist circumference.

These findings show that intensity level plays a significant role on the effect of physical activity on CAD and metabolic syndrome risk. Specifically, moderate to high levels of intensity, duration, or volume during physical activity were all found to be associated with lower odds of developing CAD and metabolic syndrome in LEOs (Sassen et al., 2009).

Yoo, Eisenmann, & Franke (2009) subjectively examined the influence of physical activity on metabolic syndrome in 386 white male LEOs. Twenty three percent of the LEOs in the sample had metabolic syndrome and were found to have lower levels of physical activity compared to the LEOs without metabolic syndrome. Additionally, the LEO's classified as highly physically active (defined as a minimum of 150 minutes of moderate-intensity physical activity per week or a minimum of 60 min of vigorous-intensity of physical activity per week) were found to have lower BMI's, lower triglyceride levels, and higher HDL cholesterol levels compared to the LEOs classified in the low or moderate physical activity groups (Yoo, Eisenmann, & Franke, 2009). The results of this study suggest that LEOs participating in low and moderate levels of physical activity have a 3 and 2 times greater risk of developing metabolic syndrome than the highly active LEOs (Yoo, Eisenmann, & Franke, 2009).

Sleep status, shift work and CAD risk factors

In recent years, the rates of CAD and metabolic syndrome have increased. Additionally, there is evidence that the number of adults obtaining insufficient sleep on a regular basis has increased. According to the National Health Interview Survey, between 1985 and 2004 the percentage of adults who reported sleeping 6 hours or less per night increased by 6% (Knutson, 2010). It is possible that sleep duration and quality may play a

role in the development of these conditions. Research has observed a cross-sectional association between low sleep duration and quality of sleep and CAD and metabolic syndrome risk factors (Knutson, 2010; Rajaratnam et al., 2011). Additionally, sleep debt has been found to be associated with metabolic abnormalities, and may play a large part in sleep-related increases in obesity and diabetes risk (Rajaratnam et al., 2011).

Knutson (2010) reviewed over 65 articles that looked at cross-sectional analyses between sleep and measures of obesity in adults. Majority of the studies found a significant relationship between sleep duration less than 6 hours per night and the incidence of obesity or high BMI (Knutson, 2010). For example, Chaput, Despres, and Bouchard (2008) found that subjects who reported sleeping 5 to 6 hours per night gained more weight over a 6 year period than those subjects who reported sleeping 7 to 8 hours per night. Objective measures of sleep have also shown shorter sleep durations to be associated with obesity. A subset of the Coronary Artery Risk Development in Young Adults (CARDIA) study in the US done by Lauderdale et al. (2009) used wrist actigraphy to estimate sleep duration in participants ages 35-50. The participants with shorter average sleep durations were found to have higher BMIs than those with longer sleep durations. Furthermore, studies that looked at self-reported measures of sleep quality have found that a higher BMI is associated with worse quality of sleep (Knutson, 2010).

Cross-sectional studies have also found sleep duration and sleep quality to be associated with higher blood pressure and an increased incidence of hypertension (Knutson, 2010). A study done by Javaheri et al. (2008) utilized wrist actigraphy on 238 adolescents and found that low sleep efficiency was significantly associated with prehypertension. In a subset of participants from the CARDIA study, Knutson et al.

(2009) estimated sleep duration and quality from 3 to 6 days of wrist actigraphy in subjects 35-50 years old. Sleep duration and sleep quality were both found to be significantly associated with hypertension over a 5 year period. Additionally, an analysis of 4500 adult subjects who participated in the National Health and Nutrition Examination Survey in the US found that the subjects who reported sleeping ≤ 5 hours per night had increased odds of hypertension compared to those who reported sleeping 7-8 hours per night (Gangwisch et al., 2006).

Several observational studies have also reported cross-sectional associations between short sleep duration and impaired sleep quality and a greater prevalence of diabetes or (Knutson, 2010). Most of these studies found sleep durations less than or equal to 6 hours of sleep per night to be correlated with an increased odds of diabetes (Knutson, 2010). Gangwisch and colleagues (2007) found that subjects who reported sleeping ≤ 5 hours or ≥ 9 hours per night had a higher odds of diabetes than those who reported sleeping 7 hours per night over 8-10 years. Xu et al. (2010) reported that subjects (aged 50-71) who reported sleeping ≤ 6 hours per night had higher odds of diabetes compared to those subjects who reported sleeping 7-8 hours per night. Majority of studies looking at sleep and diabetes have subjectively measured sleep quality and duration; however one study done by Trento et al. (2008) used wrist actigraphy to objectively measure sleep duration and quality and found no difference in total sleep time between the subjects with type 2 diabetes and the control group, however those with type 2 diabetes were found to have worse quality of sleep compared to the control group.

Shift work and overtime are both essential parts of the law enforcement profession, and are common practices among police departments worldwide (Violanti et

al., 2009). However, very little research has been done specifically looking at the effects that shift work can have on the health status of LEOs (Violanti et al., 2009). Sleep deprivation, a common denominator in most forms of shift work, including police work, has been found to have serious metabolic and cardiovascular consequences (Karlsson et al., 2001). Previous studies have found that shift work and overtime may be associated with the metabolic syndrome, thus contributing to an increased risk of CAD (Violanti et al., 2009). Shift work has been found to have metabolic effects, including abdominal obesity, lower HDL cholesterol, higher triglycerides, and glucose intolerance (Ma et al., 2011; Violanti et al., 2009). Furthermore, previous research suggests that shift work and sleep deprivation independently lead to the development of individual components of CAD and metabolic syndrome (Wolk & Somers, 2007).

A cross-sectional study done by Ghiasvand et al. (2006) looked at the relationship between shift work and lipid disorders. High serum total cholesterol and high LDL-C level were found to be more common in the shift workers than the day workers, regardless of age. However, they found no difference in HDL-C and triglyceride levels, fasting blood glucose and blood pressure between shift working and day working. The results of this study suggest that shift work is a risk factor for lipid disorders. Knutsson and Boggild (2000) found that shift work affects triglycerides, cholesterol, body mass index, and the distribution of abdominal fat. Karlsson, Knutsson, and Lindahl (2001) reported that obesity, high triglyceride levels, and low HDL cholesterol seemed to occur more often in shift workers compared to day workers.

Shift work and overtime have been associated with decreased sleep quantity and quality, particularly among LEOs (Ma et al., 2011; Violanti et al., 2009). The literature

has found significant evidence that suggests that sleep duration is indicative to waist circumference, BMI, body fat percent, insulin and glucose serum levels, and insulin resistance (Violanti et al., 2009). LEOs working the midnight shift, rotating shifts, or overtime have an even greater risk of incurring sleep debt, thus increasing their risk of obesity and diabetes (Rajaratnam et al., 2011). Additionally, a loss of two hours of sleep a night for one week has been found to induce decreases in job performance comparable to those seen after being awake for 24 hours. Therefore, LEOs suffering from chronic sleep deficiency also risk negatively affecting job performance (Rajaratnam et al., 2011).

A subjective study done by Violanti et al. (2009) looked at whether atypical work hours were associated with metabolic syndrome among LEOs. They found that the LEOs who worked the midnight shifts, combined with short sleep duration (< 6 hours) or increased amounts of overtime work had a higher mean number of metabolic syndrome components compared to the officers who worked the day shifts. Additionally, after adjusting for gender, age, and demographic variables, they found that the average number of metabolic syndrome risk factors was significantly higher in the LEOs who worked the midnight shift in addition to overtime greater than 1.7 hours per week. The results of this study agree with other research that has looked at sleep deprivation and shift work, suggesting that the LEOs working the midnight shift are more likely to be sleep deprived due to difficulties sleeping during the daylight hours. This may contribute to the development of metabolic disorders due the harmful effects that sleep debt can have on carbohydrate metabolism and endocrine function (Violanti et al., 2009).

Rajaratnam and colleagues (2011) looked at sleep disorder risk and self-reported health, safety, and performance outcomes in LEOs from the United States and Canada.

The officers participated in either an online (n = 3693) or an on-site (n = 1264) screening and monthly follow-up surveys between July 2005 and December 2007. It was determined that 40.4% of LEOs reported having symptoms consistent with at least one sleep disorder. The LEOs who screened positive for obstructive sleep apnea were found to have a significantly increased risk of diagnosed diabetes and CAD. Excessive sleepiness was also found to be common among LEOs; almost half of the LEO population reported having fallen asleep while driving and approximately one fourth reported that they fall asleep while driving one to two times per month. Previous studies have found obstructive sleep apnea (OSA) to be associated with hypertension, CAD, diabetes, and stroke, regardless of percent body fat, while insomnia is a risk factor for depression and hypertension (Rajaratnam et al., 2011). Untreated OSA and insomnia may therefore contribute to the prevalence of the metabolic syndrome and CAD in LEOs, as well as contribute to absenteeism and productivity losses by causing functional impairments while on the job (Rajaratnam et al., 2011).

Conclusion

Maintaining optimal levels of health is critical for law enforcement officers. Although law enforcement can be a demanding and dangerous occupation, it is primarily a sedentary occupation with only occasional periods of physical activity. These periods of physical activity are insufficient to maintain fitness levels necessary for LEOs to effectively perform their job duties (Boyce et al., 2008). Leading a sedentary lifestyle may increase an individual's risk for developing obesity, hypertension, dyslipidemia, and prediabetes (Laaksonen et al., 2002, Lakka et al., 2003, Sassen et al., 2010). A higher level of either physical activity plays an important role in reducing the CAD mortality

(Franke & Anderson, 1994). Studies have found that the severity of certain CAD risk factors can be decreased with an increase in exercise capacity and leisure time physical activity in LEOs (Williams et al., 1987). Additionally, intensity level plays a significant role on the effect of physical activity on CAD and metabolic syndrome risk. LEOs participating in low and moderate levels of physical activity have a 3 and 2 times greater risk of developing metabolic syndrome than highly active LEOs (Yoo, Eisenmann, & Franke, 2009). Participation in moderate to high levels of physical activity is associated with lower odds of developing CAD and metabolic syndrome in LEOs (Sassen et al., 2009).

Shift work and overtime are both essential parts of the law enforcement profession, and are common practices among police departments worldwide (Violanti et al., 2009). Shift work has been found to have metabolic effects, including abdominal obesity, lower HDL cholesterol, higher triglycerides, and glucose intolerance (Ma et al., 2011; Violanti et al., 2009). Low sleep duration and impaired quality of sleep, common denominators in most forms of shift work, including police work, have also been found to have serious metabolic and cardiovascular consequences (Karlsson et al., 2001; Rajaratnam et al., 2011). LEOs working the midnight shift are more likely to be sleep deprived and have a higher mean number of metabolic syndrome components compared to officers who work the day shifts (Violanti et al., 2009). Furthermore, untreated OSA and insomnia may also contribute to the prevalence of the metabolic syndrome and CAD in LEOs in addition to contributing to absenteeism and productivity losses by causing functional impairments while on the job (Rajaratnam et al., 2011).

Maintaining adequate physical activity levels and sleep status may decrease a LEO's risk of developing chronic disease as well as providing some level of requisite physical fitness to perform essential job tasks. Efforts to improve the CAD risk profile and subsequently prevent cardiovascular morbidity and mortality in LEOs should focus on increasing physical activity levels, effectively improving physical fitness, and improving sleep variables (Sassen et al., 2010). Future research needs to be done specifically looking at the effects of shift work and sleep on the health status of LEOs.

Chapter III

Methodology

Experimental Approach to the Problem

This cross-sectional study conducted a descriptive assessment of health-related behavioral outcomes in LEOs. Sleep and physical activity outcomes were correlated to measures of health to identify potential relationships. The behavioral outcomes of physical activity and sleep served as the independent variables and CAD and metabolic syndrome risk factors served as the dependent variables.

Subjects

A convenience sample composed of 40 male and female LEOs from a large Division I University Police Department was invited to participate in this study. Twenty-seven chose to participate in the medical history portion of the study. Out of those 27 officers, 17 completed the entire study. Subjects were between 24-55 years of age. Law enforcement administrators and officers participated in this study. The administrators worked (5) eight hour days and officers worked (4) ten hour days each week. The shift schedule was as follows: administrators worked 0900 to 1700 hours, first shift worked 0700 to 1700, second shift worked 1600 to 0200, and third shift worked 2200 to 0800. Table 1 describes the demographic characteristics of the sample. The subjects completed a medical history questionnaire and provided written informed consent prior to participating in the study. All study procedures were approved by the University's Institutional Review Board prior to initiation of the study.

Table 3.1. Demographic characteristics of the sample.

| Variable | Mean | ± | SD | % |
|----------------------------|-------|---|------|------|
| Shift | | | | |
| First shift (n=7) | | | | 25.9 |
| Second shift (n=5) | | | | 18.5 |
| Third shift (n=6) | | | | 22.2 |
| Administrator (n=7) | | | | 25.9 |
| Sex | | | | |
| Female (n=3) | | | | 11.1 |
| Male (n=24) | | | | 88.9 |
| Age (yr; n=22) | 33.6 | ± | 8.4 | |
| Height (cm; n=16) | 178.9 | ± | 7.5 | |
| Body mass (kg; n=16) | 86.3 | ± | 10.8 | |
| Abdominal circ. (cm; n=18) | 93.0 | ± | 9.4 | |
| Hip circ. (cm; n=18) | 102.8 | ± | 5.7 | |

SD: standard deviation; Circ.: Circumference.

Procedures

Subjects reported to the University's Exercise Physiology Laboratory for testing. The subjects' age, sex, race/ethnicity and smoking/tobacco use was reported. Standing height was measured (to the nearest 0.1 cm) without shoes using a wall mounted stadiometer (Seca 216, Hanover, MD). Body mass was measured (to the nearest 0.1 kg) without shoes using a digital weighing scale (Model D1-10, Teraoka Weigh-System PTE. LTD., Singapore). Waist circumference was measured following American College of Sports Medicine Guidelines (ACSM, 2010b) using a fiberglass anthropometric tape (Anthrotape, Rosscraft Innovations Incorporated, Vancouver, B.C.). A horizontal measure was taken at the narrowest portion of the subject's torso between the umbilicus and xiphoid process. The subject was standing, arms at sides and feet together, when the measurement was taken and the flexible tape measure was laid flat against the skin, making sure to avoid gaps between the skin and tape. The average of two measures was used and a third measure was taken if the measurements were not within 5 mm (ACSM,

2010b). Abdominal circumference was measured following American College of Sports Medicine Guideline (ACSM, 2010b) using a fiberglass anthropometric tape (Anthrotape, Rosscraft Innovations Incorporated, Vancouver, B.C.). A horizontal measure was taken at the greatest anterior extension of the abdomen at the level of the umbilicus. The subject was standing, arms at sides and feet together, when the measurement was taken and the flexible tape measure was laid flat against the skin, making sure to avoid gaps between the skin and tape. The average of two measures was used and a third measure was taken if the measurements were not within 5 mm (ACSM, 2010b). Resting blood pressure was measured manually using a sphygmomanometer (American Diagnostic Corporation, Germany) and a stethoscope (Lightweight II S.E., 3M Littmann Brand, St. Paul, MN). The subjects were instructed to abstain from caffeine and smoking for 30 minutes prior to the measurement; any prior stimulant usage was documented. The subject was seated in a chair with their feet on the floor and their arm supported at heart level for at least 5 minutes prior to the measurement. Two blood pressure measurements were made, one minute apart (ACSM, 2010b). Total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol level, and glucose levels were obtained via the police department's participation in the University's Wellness Program. A Cholestech LDX (Cholestech Corporation, Hayward, CA) was used to obtain the cholesterol data via finger stick. Subjects signed a medical release form to provide the investigators with consent to obtain these data.

Risk factor thresholds for CAD were based on the American College of Sports Medicine (2010c) criteria for coronary artery disease. Positive risk factors include: age (men \geq 45 years, women \geq 55 years), family history (myocardial infarction, coronary

revascularization, or sudden death before 55 years of age in a first-degree male relative, or before 65 years of age in a first-degree female relative), cigarette smoking (current cigarette smoker, quit smoking within the previous six months, or exposure to environmental smoke), obesity (body mass index $\geq 30 \text{ kg}\cdot\text{m}^2$ or waist girth $> 102 \text{ cm}$ for men and $> 88 \text{ cm}$ for women), hypertension (systolic blood pressure $\geq 140 \text{ mm Hg}$ and/or diastolic blood pressure $\geq 90 \text{ mm Hg}$, or on antihypertensive medication), dyslipidemia (low-density lipoprotein cholesterol $\geq 130 \text{ mg}\cdot\text{dL}^{-1}$ or high-density lipoprotein cholesterol $< 40 \text{ mg}\cdot\text{dL}^{-1}$ or total cholesterol $\geq 200 \text{ mg}\cdot\text{dL}^{-1}$ or on lipid-lowering medication), and prediabetes (impaired fasting glucose $\geq 100 \text{ mg}\cdot\text{dL}^{-1}$ and $< 126 \text{ mg}\cdot\text{dL}^{-1}$). High-serum high-density lipoprotein cholesterol ($\geq 60 \text{ mg}\cdot\text{dL}^{-1}$) is a negative risk factor.

Risk factor thresholds for metabolic syndrome were based on the National Cholesterol Education Program's criteria. These criteria are as follows: abdominal obesity (men $> 102 \text{ cm}$, women $> 88 \text{ cm}$), triglycerides ($\geq 150 \text{ mg}\cdot\text{dL}^{-1}$), high-density lipoprotein cholesterol (men $< 40 \text{ mg}\cdot\text{dL}^{-1}$, women $< 50 \text{ mg}\cdot\text{dL}^{-1}$), blood pressure (systolic $\geq 130 \text{ mm Hg}$ and/or diastolic $\geq 85 \text{ mm Hg}$), and fasting glucose ($\geq 110 \text{ mg}\cdot\text{dL}^{-1}$). The criteria for blood pressure and fasting glucose are different from ACSM; these variables were analyzed using ACSM criteria (ACSM 2010b).

Physical activity level was assessed through the use of an accelerometer (GT1M, ActiGraph Inc., Pensacola, FL). Of the 27 subjects, 14 (51.9%) participated in the physical activity portion of the study. Seven (50%) of the subjects wore the accelerometer for 3 or more days (Table 3.2). Daily averages were calculated for subjects who wore the device multiple days. The accelerometer was worn on the subjects'

waist band in the right mid-axillary line during all waking hours while off- and on-duty (on-duty was defined as any day that the subject had to report to work and included physical activity time before and after work), except for any water activities (e.g., bathing, swimming, etc.). The accelerometer provided data in the form of step counts and activity counts. The activity count data was used to quantify the volume, intensity, frequency, and duration of the subjects' physical activity. The following activity count thresholds were used to define sedentary (0-99 ct·min⁻¹), light (100-759ct·min⁻¹), lifestyle (760-1951 ct·min⁻¹), moderate (1952-5724 ct·min⁻¹), and vigorous (≥ 5725 ct·min⁻¹) physical activity intensities (Freedson et al., 1998). In addition, moderate and vigorous intensity physical activity categories were collapsed into one category that represents moderate-to-vigorous physical activity (i.e., ≥ 1952 ct·min⁻¹). In addition, moderate-to-vigorous physical activity (MVPA) was tracked in an accumulated fashion and in bouts lasting at least 10 consecutive minutes. Bout minutes were assessed as current physical activity recommendations for health benefits suggest that moderate-to-vigorous physical activity must be performed for at least 10 consecutive minutes to count toward the 150 min·wk⁻¹ total (Haskell et al., 2007). The accelerometer was downloaded to a personal computer and the data were evaluated using the manufacturer's software (ActiLife Version 5, Pensacola, FL). To enhance the validity of the accelerometer data, only data where the subjects wore the accelerometer for at least 10 hours per day were used for analysis. Previous literature has found that wearing an accelerometer for 10 hr·d⁻¹ or more accurately represents physical activity (Masse et al., 2005). Non-wear periods were defined as periods of at least 20 consecutive minutes of zero activity counts.

Sleep quality and quantity was assessed through the use of accelerometry (ActiSleep, ActiGraph Inc., Pensacola, FL). Actigraphic sleep assessment has been found to be a valid assessment of sleep versus wake patterns when compared to criterion methods (Tyron, 2004). Of the 27 subjects, 15 (55.5%) participated in the sleep portion of the study. All 15 (100%) of the subjects wore the sleep monitor for 3 or more days (Table 3.2). Daily averages were calculated for sleep outcomes across the 3 days. ActiSleep monitors were placed on an elastic band and worn around the subjects' wrist when going to sleep. The device measured sleep onset (the first minute that the device's algorithm scores "asleep"), sleep latency (the amount of time it takes to fall asleep), total sleep time (the total number of minutes scored as "asleep"), number and duration of awakenings, total time in bed, wake after sleep onset (the total number of minutes the subject was awake after sleep onset occurred), sleep efficiency (number of sleep minutes divided by the total number of minutes the subject was in bed), and total counts (the total actigraphy counts summed together for the entire sleep period). The device was downloaded to a personal computer and evaluated using the manufacturer's software (ActiLife Version 5). Each subject maintained a sleep log indicating what time they fell asleep, any awakenings during the sleep period, and the final wake time.

Table 3.2. Description of the number of days that subjects wore the sleep monitor and physical activity accelerometer.

| Days monitor was worn | # of subjects wearing sleep monitor (n=15) | # of subjects wearing accelerometer (n=14) |
|-----------------------|--|--|
| 1 Day | 0 | 3 |
| 2 Days | 0 | 4 |
| 3 Days | 7 | 6 |
| 4 Days | 4 | 0 |
| 5 Days | 4 | 1 |

Statistical Analysis

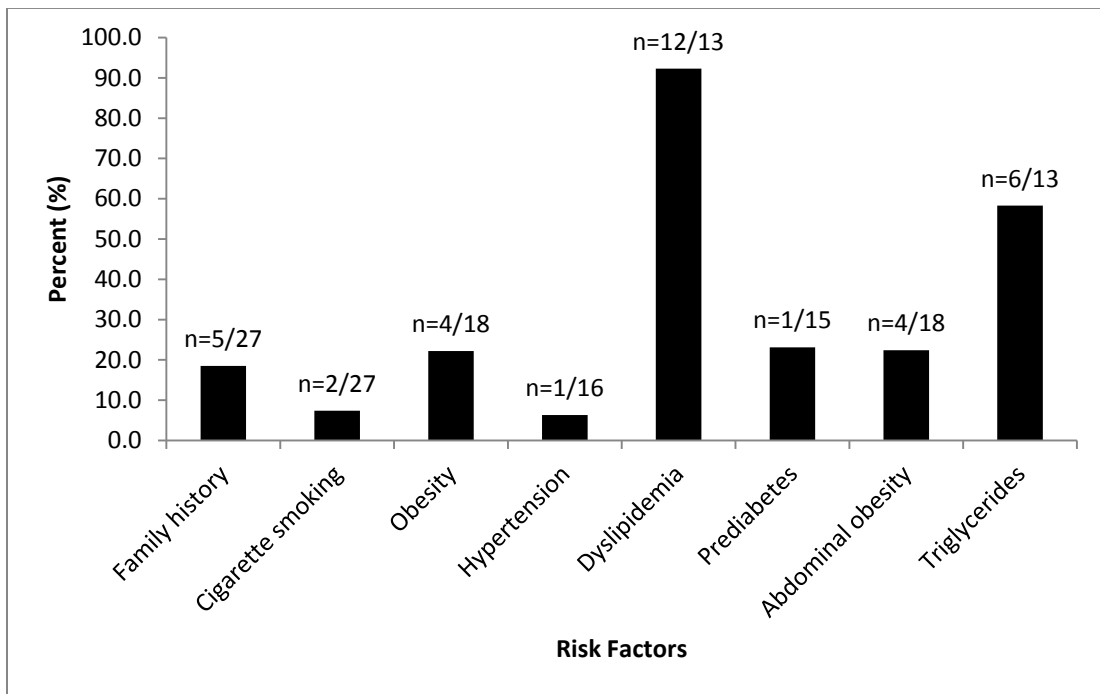
Basic statistics (mean \pm standard deviation) was used to describe the participants' health behaviors, and CAD and metabolic syndrome risk factors. Pearson product moment correlations were used to assess the relationship between sleep and physical activity outcomes versus chronic disease risk factors. The normality of each variables' distribution were evaluated with Fisher's skewness coefficient (Coefficient = skewness / standard error of skewness). A distribution with a skewness coefficient outside of an absolute value of 1.96 was considered to be significantly skewed. The variables that were skewed were total cholesterol, triglycerides, LDL cholesterol, combined light/lifestyle physical activity, and on-duty, off-duty, and combined vigorous/very vigorous physical activity. For the cholesterol data, total cholesterol was presented for all 14 subjects, while the triglycerides and LDL cholesterol were presented for only the subjects who were fasting. The skewed physical activity variables were most likely due to a small number of subjects exercising for 45 minutes or more. The correlation analysis was run with and without these subjects to determine if there was any effect on the relationship between the physical activity levels and CAD risk factors and determined that these outliers did not change the outcome. The level of significance was set at $P < 0.05$ for all statistical analyses.

Chapter IV

Results

Figure 4.1 and Table 4.1 display the prevalence of cardiovascular disease and metabolic syndrome risk factors in the sample. Most noteworthy were the prevalence of low HDL cholesterol (84.6%) and elevated triglyceride levels (58.3%). Additionally, 33.3% of officers were classified as moderate risk according to American College of Sports Medicine risk stratification criteria, which is defined as having 2 or more positive risk factors for coronary artery disease (Table 4.3).

Figure 4.1. Prevalence of coronary artery disease and metabolic syndrome risk factors in university law enforcement officers.



n: represents the number of subjects who qualified for the risk factor out of the total number of subjects that reported data for a given risk factor.

Table 4.1. Description of the prevalence of coronary artery disease and metabolic syndrome risk factors in university law enforcement officers.

| | Mean ¹ | ± | SD | % (n) |
|---|-------------------|---|------|--------------|
| Family history | | | | |
| Yes | | | | 18.5 (5/27) |
| No | | | | 81.5 (22/27) |
| Smoking status | | | | |
| Smoker | | | | 7.4 (2/27) |
| Nonsmoker | | | | 92.6 (25/27) |
| Obesity | | | | |
| BMI ≥ 30 kg·m ⁻² | 26.9 | ± | 2.5 | 18.8 (3/16) |
| BMI < 30 kg·m ⁻² | | | | 81.3 (13/16) |
| Waist circumference > 102 cm | 90.6 | ± | 8.5 | 11.1 (2/18) |
| Waist circumference ≤ 102 cm | | | | 88.9 (16/18) |
| Hypertension ² | | | | |
| Systolic blood pressure ≥ 140 mmHg | 122.9 | ± | 5.8 | 6.3 (1/16) |
| Systolic blood pressure < 140 mmHg | | | | 93.8 (15/16) |
| Diastolic blood pressure ≥ 90 mmHg | 76.5 | ± | 5.4 | 6.3 (1/16) |
| Diastolic blood pressure < 90 mmHg | | | | 93.8 (15/16) |
| Dyslipidemia ^{3,4} | | | | |
| Total cholesterol ≥ 200 mg/dl | 180.6 | ± | 45.3 | 35.7 (5/14) |
| Total cholesterol < 200 mg/dl | | | | 64.3 (9/14) |
| LDL cholesterol ≥ 130 mg/dl | 120.3 | ± | 35.6 | 46.2 (6/13) |
| LDL cholesterol < 130 mg/dl | | | | 53.8 (7/13) |
| HDL cholesterol < 40 mg/dl | 33.9 | ± | 7.5 | 84.6 (11/13) |
| HDL cholesterol ≥ 40 mg/dl | | | | 15.4 (2/13) |
| Triglycerides ≥ 150 mg/dl | 158.8 | ± | 60.1 | 58.3 (7/12) |
| Triglycerides < 150 mg/dl | | | | 41.7 (5/12) |
| Prediabetes | | | | |
| Fasting glucose ≥ 100 mg/dl | 88.3 | ± | 2.4 | 23.1 (3/13) |
| Fasting glucose < 100 mg/dl | | | | 76.9 (10/13) |

¹Represents mean value for all subjects for a given variable.

²Percentages include subjects with high blood pressure or reported using antihypertensive medications.

³Percentages include subjects with abnormal cholesterol values or reported using lipid-lowering medications.

⁴Mean and standard deviation do not include subjects on lipid-lowering medications.

BMI: Body mass index; LDL: Low density lipoprotein cholesterol; HDL: High density lipoprotein cholesterol.

*Risk factor thresholds are based on American College of Sports Medicine (2010) and National Cholesterol Education Program (2002) criteria.

Table 4.2 displays the prevalence of medication use reported by the sample.

Table 4.2. Type and prevalence of medication use reported by 27 University law enforcement officers.

| Medication type | % |
|----------------------------|------|
| Hypercholesterolemia (n=4) | 14.8 |
| Hypertension (n=2) | 7.4 |
| Other (n=7) | 25.9 |

Table 4.3. Prevalence of coronary artery disease (CAD) and metabolic syndrome risk factors (RF) by risk factor frequency category in 27 university law enforcement officers.

| Number of risk factors | CAD RF prevalence (%; n) | Metabolic syndrome RF prevalence (%; n) |
|--------------------------------|--------------------------|---|
| Not reported or 0 risk factors | 40.7 (11) | 59.3 (16) |
| 1 risk factor | 25.9 (7) | 14.8 (4) |
| 2 risk factors | 18.5 (5) | 18.5 (5) |
| 3 risk factors | 11.1 (3) | 7.4 (2) |
| 4 risk factors | 3.7 (1) | 0.0 (0) |

The mean total sleep time for all subjects was 392.9 minutes (6.5 hr) and the mean total time in bed for all subjects was 455.3 minutes (7.6 hr). However, sleep outcomes were significantly different among shifts (Tables 4.4 & 4.5). Administrators or first shift LEOs were found to have a greater total sleep time (419.6 vs. 352.9 min),

greater total time in bed (495.5 vs. 395.0 min), and greater wake time after sleep onset (73.6 vs. 39.1 min) compared to the officers working second or third shifts (Table 4.5). However, the officers on the second and third shifts had greater sleep efficiency (89.6% vs. 84.6%) and fewer awakenings (13.9 vs. 23.4) compared to the administrators and officers on first shift (Table 4.5).

Table 4.4. Accelerometer derived sleep outcomes in 15 law enforcement officers, stratified by shift.

| | All subjects (n=15) | | First shift (n=2) | | Second shift (n=4) | | Third shift (n=2) | | Admin. (n=7) | |
|-------------------------|---------------------|---------|-------------------|---------|--------------------|--------|-------------------|---------|--------------|---------|
| | Mean | ± SD | Mean | ± SD | Mean | ± SD | Mean | ± SD | Mean | ± SD |
| Total sleep time (min) | 392.9 | ± 60.8 | 453.0 | ± 115.0 | 355.8 | ± 58.6 | 347.1 | ± 53.2 | 410.1 | ± 32.7 |
| Total time in bed (min) | 455.3 | ± 74.8 | 531.5 | ± 120.5 | 397.3 | ± 66.4 | 390.4 | ± 74.8 | 485.2 | ± 29.6 |
| Sleep efficiency (%) | 86.6 | ± 3.9 | 84.9 | ± 2.4 | 89.8 | ± 1.8 | 89.1 | ± 3.4 | 84.5 | ± 3.9 |
| Sleep latency (min) | 2.6 | ± 2.3 | 1.3 | ± 1.4 | 3.2 | ± 1.6 | 2.7 | ± 1.9 | 2.5 | ± 3.1 |
| Number of awakenings | 19.6 | ± 6.2 | 26.5 | ± 0.7 | 13.6 | ± 3.7 | 14.5 | ± 5.4 | 22.5 | ± 4.5 |
| Wake after sleep (min) | 59.8 | ± 24.0 | 77.1 | ± 6.9 | 38.3 | ± 10.0 | 40.7 | ± 23.6 | 72.6 | ± 21.6 |
| Awakening length (min) | 3.3 | ± 0.6 | 3.1 | ± 0.4 | 3.2 | ± 0.9 | 3.1 | ± 0.2 | 3.4 | ± 0.6 |
| Total counts | 28244 | ± 11419 | 30877 | ± 10599 | 21525 | ± 8029 | 25763 | ± 18531 | 32039 | ± 12034 |

Admin.: Administrators.

Table 4.5. Accelerometer derived sleep outcomes in 15 law enforcement officers, stratified by work shift.

| Sleep variables | Administrators& First Shift (n = 9) | | Second & Third Shifts (n = 6) | | p-value |
|------------------------------|--|---------|----------------------------------|---------|--------------------|
| | Mean | ± SD | Mean | ± SD | |
| Total sleep time (min) | 419.6 | ± 53.0 | 352.9 | ± 51.4 | 0.031 [*] |
| Total time in bed (min) | 495.5 | ± 53.7 | 395.0 | ± 61.5 | 0.005 [†] |
| Sleep efficiency (%) | 84.6 | ± 3.5 | 89.6 | ± 2.1 | 0.008 [†] |
| Sleep latency (min) | 2.2 | ± 2.7 | 3.0 | ± 1.5 | 0.540 |
| Number of awakenings | 23.4 | ± 4.3 | 13.9 | ± 3.8 | 0.001 [†] |
| Wake after sleep onset (min) | 73.6 | ± 19.0 | 39.1 | ± 13.1 | 0.002 [†] |
| Mean awakening length (min) | 3.3 | ± 0.5 | 3.2 | ± 0.7 | 0.702 |
| Total counts | 31781 | ± 11086 | 22938 | ± 10590 | 0.148 |

p-value represents the comparison of administrators and first shift officers versus second and third shift officers by sleep variable.

*Significant at the 0.05 level.

†Significant at the 0.01 level.

Table 4.6 displays the sample’s daily accumulation of physical activity stratified by work shift. There was no significant difference in wear time between on- and-off duty days. The officers wore the accelerometers for an average of 714.5 minutes (673.2 minutes off-duty and 728.8 minutes on-duty). The officers spent more time being sedentary while on-duty compared to off-duty (519.0 minutes vs. 380.5 minutes). Additionally, the officers only spent 24.4 minutes in MVPA per day (28.0 minutes off-duty and 27.4 minutes on-duty) and 9.3 minutes of MVPA per day in bouts of 10 minutes or more (14.1 minutes off-duty and 7.2 minutes on-duty). Table 4.7 displays the sample’s off-duty, on-duty, and combined average accumulation of physical activity stratified by shift. On average, officers working second shift spent more time in sedentary activity both off-and on-duty (476.8 minutes and 645.0 minutes, respectively) compared to

officers in administration positions (312.7 minutes and 467.2 minutes, respectively). When comparing wear time between the two groups, both the administrators and the officers on the second shift wore the accelerometers for approximately the same amount of time while off-duty. However, while on-duty, the officers in administration positions wore the accelerometers much more than the officers working the second shift (732.6 minutes vs. 503.3 minutes). Interestingly, the officers on second shift only accumulated 14.5 minutes in MVPA off-duty and 19.7 minutes of MVPA on-duty, whereas administrators accumulated 41.2 minutes of MVPA while off-duty and 34.5 minutes of MVPA while on-duty.

Table 4.6. Accumulated daily physical activity stratified by work shift in university law enforcement officers.

| | Off-duty days (n=11) | On-duty days (n=10) | Combined on- and off-duty days (n=14) | p-value |
|--------------------------------------|-------------------------|------------------------|--|---------|
| | Mean \pm SD | Mean \pm SD | Mean \pm SD | |
| Wear time (min) | 673.2 \pm 53.9 | 728.8 \pm 107.6 | 714.5 \pm 80.7 | 0.230 |
| Time in sedentary (min) | 380.5 \pm 117.7 | 519.0 \pm 158.4 | 426.7 \pm 56.3 | 0.036* |
| Time in light/lifestyle (min) | 264.7 \pm 103.6 | 246.2 \pm 90.9 | 263.4 \pm 104.1 | 0.358 |
| Time in moderate (min) | 16.6 \pm 11.9 | 21.9 \pm 13.8 | 17.4 \pm 11.7 | 0.085 |
| Time in vigorous/very vigorous (min) | 11.5 \pm 19.9 | 5.5 \pm 12.4 | 7.0 \pm 13.7 | 0.256 |
| Time in MVPA (min) | 28.0 \pm 20.0 | 27.4 \pm 18.2 | 24.4 \pm 17.0 | 0.663 |
| Time in MVPA bouts (min) | 14.1 \pm 20.1 | 7.2 \pm 12.4 | 9.3 \pm 13.9 | 0.205 |

MVPA: Moderate-to-vigorous physical activity. P-value represents statistical comparison of off- versus on-duty physical

activity outcome variables. Wear time represents the daily duration the accelerometer was worn.

*Significant at the 0.05 level.

Table 4.7. Off-duty, on-duty, and combined average accumulation of physical activity characteristics in law enforcement officers, stratified by shift.

| | First Shift | | | Second Shift | | | Third Shift | | | Administration | | |
|--|---|-----------------------|---------------------------|---|------------------------|---------------------------|---|------------------|---------------------------|----------------|---------------|---------------------------|
| | Off-Duty (n=1) | On-Duty (n=1) | Combined Average (n=2) | Off-Duty (n=4) | On-Duty (n=3) | Combined Average (n=4) | Off-Duty (n=1) | On-Duty (n=1) | Combined Average (n=3) | Off-Duty (n=5) | On-Duty (n=5) | Combined Average (n=5) |
| | | | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | | | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Wear time (min) | | | 771.0 ± 193.7 | 671.0 ± 83.0 | 503.3 ± 340.1 | 665.4 ± 39.5 | | | 741.9 ± 98.1 | 678.3 ± 39.3 | 732.6 ± 58.1 | 714.7 ± 34.9 |
| Time in sedentary (min) | | | 410.5 ± 23.3 | 476.8 ± 113.7 | 645.0 ± 259.6 | 480.1 ± 50.8 | | | 393.2 ± 43.9 | 312.7 ± 72.8 | 467.2 ± 64.3 | 410.6 ± 55.9 |
| Time in light/lifestyle (min) | | | 352.8 ± 216.7 | 179.8 ± 33.3 | 218.7 ± 84.7 | 171.7 ± 24.1 | | | 325.2 ± 75.4 | 324.4 ± 89.6 | 230.9 ± 76.5 | 263.9 ± 70.2 |
| Time in moderate (min) | No Data Available* | | 7.8 ± 0.4 | 12.0 ± 9.1 | 19.7 ± 11.6 | 12.4 ± 8.0 | No Data Available *** | | 23.4 ± 10.5 | 18.0 ± 12.5 | 23.6 ± 16.0 | 21.5 ± 15.0 |
| Time in vigorous/very vigorous (min) | | No Data Available* | | 2.5 ± 5.0 | No Data Available** | 1.3 ± 2.5 | | | No Data Available*** | 23.2 ± 25.6 | 10.9 ± 16.5 | 18.7 ± 18.5 |
| Time in MVPA (min) | | | 7.8 ± 0.4 | 14.5 ± 7.4 | 19.7 ± 11.6 | 13.6 ± 7.1 | | | 23.4 ± 10.5 | 41.2 ± 21.0 | 34.5 ± 21.3 | 40.2 ± 16.8 |
| | *Constant when Work Shift = First Shift | | | **Constant when Work Shift = Second Shift | | | ***Constant when Work Shift = Third Shift | | | | | |

Upon assessment of correlations between physical activity and sleep characteristics with cardiovascular disease and metabolic syndrome risk factors, a relationship was found between blood pressure versus off-duty sedentary time, combined daily sedentary time, and sleep efficiency (Table 4.8). Specifically, systolic blood pressure had a positive relationship with off-duty sedentary time and combined daily sedentary time. Also, diastolic blood pressure had a positive relationship with sleep efficiency.

There were also significant correlations between cardiovascular and metabolic syndrome risk factors (Table 4.9). Age was positively correlated with waist circumference, abdominal circumference, and total cholesterol. Body mass index was positively correlated with waist and abdominal circumference, and diastolic blood pressure. Waist circumference was positively correlated with abdominal circumference and diastolic blood pressure. Abdominal circumference was positively correlated with both systolic and diastolic blood pressures.

Table 4.8. Correlations between physical activity and sleep outcomes versus coronary artery disease and metabolic syndrome risk factors.

| | Age | BMI | Waist circum. | Abdominal circum. | SBP | DBP | TC | HDL-C |
|-------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|--------------------|
| Off-duty sedentary time | -0.10, P=0.77, n=11 | 0.14, P=0.72, n=9 | 0.12, P=0.72, n=11 | -0.01, P=0.97, n=11 | 0.71, P=0.03*, n=9 | 0.12, P=0.77, n=9 | N/A | 0.35, P=0.65, n=4 |
| Off-duty MVPA time | -0.28, P=0.41, n=11 | -0.26, P=0.51, n=9 | -0.32, P=0.34, n=11 | -0.29, P=0.40, n=11 | -0.45, P=0.23, n=9 | -0.38, P=0.32, n=9 | N/A | 0.36, P=0.64, n=4 |
| On-duty sedentary time | -0.39, P=0.27, n=10 | -0.50, P=0.18, n=9 | -0.33, P=0.35, n=10 | -0.28, P=0.43, n=10 | 0.30, P=0.43, n=9 | -0.10, P=0.79, n=9 | N/A | -0.51, P=0.66, n=3 |
| On-duty MVPA time | 0.27, P=0.46, n=10 | -0.06, P=0.89, n=9 | -0.04, P=0.91, n=10 | 0.23, P=0.52, n=10 | -0.20, P=0.60, n=9 | 0.33, P=0.39, n=9 | N/A | 0.36, P=0.77, n=3 |
| Combined sedentary time | 0.04, P=0.90, n=14 | -0.06, P=0.86, N=12 | -0.02, P=0.96, n=14 | -0.16, P=0.58, n=14 | 0.69, P=0.01†, n=12 | 0.21, P=0.52, n=12 | 0.41, P=0.36, n=7 | -0.67, P=0.10, n=7 |
| Combined MVPA time | 0.03, P=0.91, n=14 | -0.17, P=0.60, n=12 | -0.24, P=0.41, n=14 | -0.15, P=0.60, n=14 | -0.31, P=0.33, n=12 | -0.05, P=0.87, n=12 | -0.36, P=0.44, n=7 | 0.54, P=0.21, n=7 |
| Total sleep time | 0.20, P=0.48, n=15 | -0.19, P=0.54, n=13 | -0.08, P=0.78, n=15 | -0.11, P=0.70, n=15 | -0.40, P=0.17, n=13 | -0.15, P=0.62, n=13 | 0.31, P=0.50, n=7 | -0.25, P=0.63, n=6 |
| Sleep efficiency | 0.10, P=0.73, n=15 | -0.02, P=0.95, n=13 | 0.15, P=0.58, n=15 | 0.19, P=0.49, n=15 | 0.47, P=0.10, n=13 | 0.59, P=0.03*, n=13 | 0.32, P=0.48, n=7 | -0.46, P=0.37, n=6 |

First value in each cell represents the correlation coefficient (r-value). BMI: Body mass index; Circum.: Circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; TC: Total cholesterol; HDL-C: High density lipoprotein cholesterol; MVPA: Moderate-to-vigorous physical activity; Combined MVPA time: represents off- and on-duty moderate-to-vigorous physical activity time.

*Significant at the 0.05 level.

†Significant at the 0.01 level.

**The subjects may not be the same under each measure; therefore comparisons of the strength of the correlations may not be possible.

Table 4.9. Correlation matrix between coronary artery risk factors.

| | BMI | Waist circum. | Abdominal circum. | SBP | DBP | TC | HDL-C |
|-------------------|--------------------------|--|--|---------------------------|---------------------------|--|---------------------------|
| Age | 0.47, P=0.07, n=16 | 0.60, P=0.01 [†] , n=18 | 0.59, P=0.01 [†] , n=18 | 0.22, P=0.43, n=15 | 0.39, P=0.15, n=15 | 0.66, P=0.01 [†] , n=13 | -0.56, P=0.09, n=10 |
| BMI | | 0.91, P<0.01 [†] , n=16 | 0.90, P<0.01 [†] , n=16 | 0.411, P=0.13, n=15 | 0.57, P=0.03*, n=15 | 0.42, P=0.30, n=8 | 0.10, P=0.84, n=7 |
| Waist circum. | | | 0.93, P<0.01 [†] , n=18 | 0.45, P=0.09, n=15 | 0.56, P=0.03*, n=15 | 0.48, P=0.20, n=9 | -0.16, P=0.71, n=8 |
| Abdominal circum. | | | | 0.52, P=0.05*, n=15 | 0.60, P=0.02*, n=15 | 0.46, P=0.22, n=9 | 0.01, P=0.99, n=8 |
| SBP | | | | | 0.51, P=0.06, n=15 | 0.07, P=0.87, n=8 | 0.10, P=0.84, n=7 |
| DBP | | | | | | 0.10, P=0.81, n=8 | 0.08, P=0.86, n=7 |
| TC | | | | | | | -0.11, P=0.77, n=10 |

First value in each cell represents the correlation coefficient (r-value).

BMI: Body mass index; Circum: Circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; TC: Total cholesterol; HDL-C: High density lipoprotein cholesterol.

*Significant at the 0.05 level.

[†]Significant at the 0.01 level.

**The subjects may not be the same under each measure; therefore comparisons of the strength of the correlations may not be possible.

Chapter V

Discussion

The purpose of this study was to (i) examine the physical health status of University LEOs, and (ii) to determine the relationship between physical activity and sleep outcomes versus CAD and metabolic syndrome risk factors among LEOs. The findings of this study indicate that one third of LEOs have multiple CAD risk factors, most officers are not achieving current physical activity recommendations, and unhealthy sleep habits and low physical activity levels were related to a several CAD risk factors.

Data from the present study indicated that 33% of the LEOs had two or more risk factors for CAD. Most noteworthy was the prevalence of low HDL cholesterol and elevated triglyceride levels. Additionally, greater than 38% of the LEOs had elevated total and LDL cholesterol levels. These findings are similar to previous research. For instance, Williams and colleagues (1987) found that a substantial number of LEOs were at an elevated risk for cardiovascular disease. In their sample, 76% had high total cholesterol, 26% had high triglycerides, 16% had hypertension, and 60% had high levels of body fat. Violanti et al. (2009) found that police officers presented a number of metabolic syndrome components, with the most prevalent being reduced HDL cholesterol, followed by high waist circumference and glucose intolerance. These findings are also similar to general population. Thirty-seven percent of the general adult population has reported having two or more CAD risk factors; however, only 15% of U.S. adults have reported high cholesterol levels (Centers for Disease Control and Prevention, 2003; National Center for Health Statistics, 2010).

The findings of the present study indicate that LEOs spent more time being sedentary while on-duty compared to off-duty (Table 4.6). Likewise, although not statistically different, LEOs performed about twice as much MVPA in bouts during off-duty days compared to on-duty days (Table 4.6). These data may suggest that police departments should explore strategies to improve physical activity for LEOs on workdays (e.g., before/after work, while on-duty). In addition, although LEOs accumulated 24.4 $\text{min}\cdot\text{d}^{-1}$ of combined MVPA, they only performed 9.3 $\text{min}\cdot\text{d}^{-1}$ of MVPA in bouts of 10 minutes or more. The limited amount of bout MVPA performed by these LEOs is a concern because the recommended amount of physical activity to obtain health benefits is 150 $\text{min}\cdot\text{wk}^{-1}$ or 30 min on at least 5 $\text{d}\cdot\text{wk}^{-1}$ (Haskell et al., 2007). Extrapolating the daily bout MVPA from this sample suggests that these LEOs would only obtain 43% of the weekly amount of MVPA required for health benefits (i.e., $9.3 \text{ min}\cdot\text{d}^{-1} \times 7 \text{ d}\cdot\text{wk}^{-1} = 65.1 \text{ min}\cdot\text{wk}^{-1}$; $65.1 \text{ min}\cdot\text{wk}^{-1} / 150 \text{ min}\cdot\text{wk}^{-1} = 43\%$). In the state of Kentucky, only 45.7% of adults participate in moderate physical activity for 30 $\text{min}\cdot\text{d}^{-1}$ on at least 5 $\text{d}\cdot\text{wk}^{-1}$ or vigorous physical activity for 20 $\text{min}\cdot\text{d}^{-1}$ on at least 3 $\text{d}\cdot\text{wk}^{-1}$ (Centers for Disease Control and Prevention, 2009). Additionally, in the United States, only 51% of adults participate in moderate physical activity for 30 $\text{min}\cdot\text{d}^{-1}$ on at least 5 $\text{d}\cdot\text{wk}^{-1}$ or vigorous physical activity for 20 $\text{min}\cdot\text{d}^{-1}$ on at least 3 $\text{d}\cdot\text{wk}^{-1}$ (Centers for Disease Control and Prevention, 2009). This suggests that LEOs, much like the general population, are not getting enough physical activity to maintain health. Law enforcement officers should strive to perform moderate intensity physical activity for a minimum of 30 $\text{min}\cdot\text{d}^{-1}$ on at least 5 $\text{d}\cdot\text{wk}^{-1}$ (can be accumulated in bouts lasting 10 minutes or more), vigorous intensity physical activity for a minimum of 20 $\text{min}\cdot\text{d}^{-1}$ on at least 3 $\text{d}\cdot\text{wk}^{-1}$, or a combination of moderate and

vigorous physical activity throughout the week (Haskell et al., 2007). Additional strategies to improve physical activity levels may include annual physical activity assessments to evaluate the health and fitness levels of the LEOs with an opportunity to enroll in a guided physical activity program if certain standards are not met.

The use of accumulated MVPA versus bouts of MVPA as outcome variables raises questions regarding the appropriate interpretation of physical activity levels. Obviously bouts of MVPA produce lower physical activity levels than accumulated MVPA time. However, the ACSM's and American Heart Association's physical activity recommendations clearly state that MVPA should be obtained in bouts lasting 10 min or more. Furthermore, research has found that health outcomes are associated with bout minutes. For instance, Strath and colleagues (2008) found that subjects who accumulated 30 minutes of MVPA in bouts lasting 10 or more minutes had a significantly lower BMI and waist circumference compared to subjects who accumulated 30 minutes of MVPA in non-bouts. Similarly, Catenacci et al. (2011) found that subjects who were successful at long-term weight loss accumulated more MVPA in bouts of 10 or more minutes per day than did the overweight controls. The results of both of these studies suggest that non-bout MVPA may be a useful starting point for increasing physical activity levels; however, MVPA in bouts lasting 10 or more minutes are more beneficial for an individual's health because physical activity during a sustained bout tends to be at a higher intensity level (Strath et al., 2008).

To the best of our knowledge comparisons between objectively measured physical activity occurring on- versus off-duty and between various shifts have not been reported in the literature. However, Ma et al. (2011) examined the relationship between shift work

and self-reported occupational, sports, and household physical activity levels among LEOs. The investigators indicated that LEOs who worked the afternoon shift (defined as 1200 to 1959 hours) reported the highest prevalence of hard-intensity physical activity and the most hours of high-intensity physical activity. Esquirol et al. (2009) found that rotating male shift workers had higher physical activity levels at work compared to day workers in an industrial plant. However, both of these studies used questionnaires to quantify physical activity and did not distinguish between on-duty and off-duty physical activity and the Esquirol et al. (2009) study did not distinguish physical activity levels between shifts.

In the present study, we found that the officers who worked as administrators spent more time in MVPA both on- and off-duty than did the officers on the first, second, and third shifts. One explanation for this could be that the accelerometer only detected vertical accelerations. These movements are limited when cycling, therefore the amount of physical activity done by officers assigned to bicycle patrol may have been under-reported. Additionally, there were a few select administrators who were amateur cyclists or marathoners whose high physical activity levels may have skewed the data.

In the present study, combined and off-duty sedentary times were positively associated with systolic blood pressure. To the best of our knowledge, an evaluation of the relationships between physical activity occurring on- and off-duty versus cardiovascular and metabolic syndrome risk factors in LEOs have not been reported in the literature. However, there is abundant literature evaluating the general relationship between physical activity levels versus various health outcomes. For instance, Cornelissen and Fagard (2005) conducted a meta-analysis evaluating the effect of aerobic

training on blood pressure, blood-pressure regulating mechanisms, and cardiovascular disease risk factors. They found that physical activity decreased systolic and diastolic blood pressure, most notably in those individuals who are already hypertensive. Finally, they reported that higher physical activity levels decreased body weight, waist circumference, percent body fat, insulin resistance, and increased HDL cholesterol. Additionally, Williams et al. (1987) evaluated health outcomes based on *physical fitness* levels in police officers. The investigators reported the police officers in the high fitness group had considerably lower body fat, diastolic blood pressure, total cholesterol, LDL cholesterol, and triglyceride level compared to the moderate and low fitness groups.

In the present study, no correlations were found between physical activity/sedentary outcomes versus anthropometric and cholesterol-related outcomes. However, previous literature has found sedentary time and time spent in MVPA to be related to a number of cardiovascular disease and metabolic syndrome risk factors in both the general population and in LEOs. A cross-sectional study conducted by Sassen and colleagues (2009) assessed the effects of physical activity on cardiovascular disease and metabolic syndrome risk factors in 1298 healthy police officers. They found significant inverse associations between physical activity and cardiovascular disease and metabolic syndrome risk factors. The most fit LEOs had an 87% lower risk of developing metabolic syndrome than the least fit LEOs. Furthermore, LEO's who spent more time in MVPA tended to have a smaller waist circumference. Additionally, Yoo, Eisenmann, and Franke (2009) found that the LEOs without metabolic syndrome had higher levels of physical activity compared to the LEO's with metabolic syndrome. Furthermore, the LEO's classified as highly physically active (defined as a minimum of 150 minutes of moderate-

intensity physical activity per week or a minimum of 60 min of vigorous-intensity of physical activity per week) were found to have lower BMI's, lower triglyceride levels, and higher HDL cholesterol levels compared to the LEO's classified in the low or moderate physical activity groups. Overall, the literature shows that physical activity level plays a significant role in the risk of developing CAD and metabolic syndrome. Specifically, moderate-to-vigorous levels of physical activity were found to be associated with lower odds of developing CAD and metabolic syndrome in LEOs as well as the general population (Sassen et al., 2009). The lack of significant relationships between most physical activity and health outcomes in the present study may have been due, in part, to a limited sample size.

In the present study, administrators and first shift officers had a greater total sleep time and time in bed compared to second and third shift officers (Table 4.5). Additionally, the officers on second and third shifts had greater sleep efficiency and a lower number of awakenings compared to the administrators or officers on first shift. These results are comparable to the general population. According to the National Health Interview Survey, 28.8% of civilian regular daytime shift workers reported getting less than 6 hours of sleep per night compared to 44.0% of civilian night shift workers (National Health Interview Survey, 2010). To the best of our knowledge, an evaluation of shift work and sleep characteristics in LEOs has not been reported in the literature. However, other investigations have reported an association between low sleep duration and quality of sleep versus CAD and metabolic syndrome risk factors (Knutson, 2010; Rajaratnam et al., 2011). Sleep debt has been found to be associated with metabolic abnormalities and may play a large part in sleep-related increases in obesity and diabetes

risk (Rajaratnam et al., 2011). In the general population, 44.3% of physically inactive adults report getting less than 6 hours of sleep per night, and 33.3% of obese adults report getting less than 6 hours of sleep per night (National Health Interview Survey, 2006). Sleep deprivation, a common denominator in most forms of shift work, including police work, has been found to have serious metabolic and cardiovascular consequences (Karlsson et al., 2001). Previous studies have found that shift work and accumulated overtime may be associated with the metabolic syndrome, thus contributing to an increased risk of CAD (Violanti et al., 2009). Shift work has also been found to have metabolic effects, including abdominal obesity, lower HDL cholesterol, higher triglycerides, and glucose intolerance (Ma et al., 2011; Violanti et al., 2009). Furthermore, previous research suggests that shift work and sleep deprivation independently lead to the development of individual components of CAD and metabolic syndrome (Wolk & Somers, 2007).

Although our data did not reveal many significant relationships between sleep and risk factors for CAD and metabolic syndrome, sleep appears to be important for health, cognitive performance, and decision making. Studies have repeatedly found that sleep deprivation has a negative impact on cognitive performance, motor function, and mood (Durmer & Dinges, 2005). In addition, Van Dongen et al. (2003) assessed the impact of sleep restriction on neurobehavioral functions and sleep physiology over 14 days in healthy adults. They found decreased vigilance, working memory, and cognitive performance to be significantly associated with sleep periods chronically limited to 4 and 6 hours per night. Furthermore, sleep deprivation negatively affects decision making skills, which are especially critical in a law enforcement setting (Harrison & Horne,

2000). In the present study, second and third shift officers averaged 5.9 hours of sleep per night. Thus, police departments should consider strategies to enhance sleep quality and quantity among susceptible officers working these shifts.

Although no relationships were found between sleep outcomes and health outcomes in the present study, the literature has observed a cross-sectional association between low sleep duration and cardiovascular disease and metabolic syndrome risk factors. Studies using both wrist actigraphy and self-report to measure sleep have found that subjects with shorter sleep durations had a higher BMI and gained more weight than subjects with sleep durations of 7-8 hours per night (Chaput, Despres, & Bouchard, 2008; Lauderdale et al., 2009). Several studies have indicated that sleeping less than 6 hours per night or more than 9 hours per night increases the risk of diabetes (Gangwisch et al., 2007; Knutson, 2010, Xu et al., 2010). Several studies have also found a significant relationship between sleep duration and hypertension; sleeping ≤ 5 hours per night increases the odds of hypertension (Gangwisch et al., 2006; Knutson et al., 2009).

The literature on sleep duration and quality in LEOs is consistent with the findings from the general population. Violanti et al. (2009) found that the LEOs who worked the midnight shifts, combined with short sleep duration (< 6 hours) or increased amounts of overtime work had a higher mean number of metabolic syndrome risk factors compared to the officers who worked the day shifts. Additionally, Rajaratnam et al. (2011) found that 40% of LEOs in the sample screened positive for at least 1 sleep disorder and that 34% screened positive for obstructive sleep apnea. They found that the LEOs who screened positive for obstructive sleep apnea had an increased risk of diagnosed cardiovascular disease and diabetes. The literature suggests that LEOs are at a

greater risk of cardiovascular disease and metabolic syndrome because they often work overnight shifts, rotating shifts, or both (Rajaratnam et al., 2011).

Despite the lack of relationships between sleep and health outcomes in the present study, we feel that obtaining adequate amounts of sleep is still critical to the health of LEOs. Sleep deprivation can seriously impair neurobehavioral functions and negatively affect decision making skills, making adequate amount of sleep essential to the health and performance of LEOs (Harrison & Horne, 2000; Van Dongen et al., 2003). A review done by Knauth and Hornberger (2003) examined strategies to combat sleepiness at work. The literature found many changes that can be made to the shift work design to prevent or reduce problems caused by shift work. Avoiding permanent night work, working a maximum of 3 night shifts in a row, having a forward shift rotation of morning, afternoon, night, having at least 2 days off after working the night shift, working a maximum of 5 to 7 consecutive days, and shift duration of 8 or fewer hours are all strategies that have been found to decrease problems of circadian rhythms adaptation, decrease the accumulation of sleep deficits, decrease the accumulation of fatigue, and decrease potential long-term negative health effects (Knauth & Hornberger, 2003). Several studies have also found nighttime napping to be an effective strategy at preventing some of the effects of working the night shift (Takeyama, Kubo, & Itani, 2005). Allowing nighttime naps of 60-90 minutes during the night shift may prevent disturbances to the circadian rhythms, reduce sleepiness, and increase alertness during the period following the nap (Takeyama, Kubo, & Itani, 2005).

Interestingly, diastolic blood pressure was found to have a positive relationship with sleep efficiency and systolic blood pressure was found to be trending towards a

positive relationship with sleep efficiency. These findings are not supported by previous research. Much of the literature has found that self-reported poor sleep quality and short sleep duration are associated with higher blood pressure and a higher prevalence of hypertension (Knutson, 2010). One study conducted on adolescents utilized wrist actigraphy and found that low sleep efficiency was significantly associated with prehypertension (Javaheri et al., 2008). One possible explanation for the results in this study is the limited sample size. There were outliers for both sleep efficiency versus systolic blood pressure and sleep efficiency versus diastolic blood pressure that may have affected these correlations. Specifically, we noted that the LEOs who had higher sleep efficiency had lower total sleep time. Perhaps these LEOs were falling asleep quickly because they were exhausted from working (especially on 2nd and 3rd shifts; Table 4.4), thus affecting this relationship.

In the present study, we found significant correlations between many of the cardiovascular disease risk factors. However, the most interesting finding was that age was positively correlated with waist circumference, abdominal circumference, and total cholesterol. For older LEOs who want to perform their job effectively and retire in good health, physical training and dietary programs are imperative. Yearly physicals to assess CAD and metabolic syndrome risk factors, health education and nutrition seminars, access to physical activity programs, yearly physical activity assessments, and screenings for sleep disorders are just some examples of programs that could benefit the health and performance of older LEOs.

This study had several limitations. First, this was composed of a small convenience sample of LEOs. Had the sample size been larger, it is possible that more

significant relationships may have been found between physical activity and sleep outcomes versus CAD and metabolic syndrome risk factors. However, given a smaller sample size, we were able to conduct a novel assessment of objective physical activity and sleep levels of officers while on- and off-duty. These data provide a unique view of activity and sleep levels for LEOs. Furthermore, our target sample was university law enforcement officers. Thus, the number of potential participants for this study was relatively small at a single university. To the best of our knowledge, this was the first study to be conducted on university officers. Second, only male LEOs wore sleep monitors and accelerometers. Thus, we cannot make generalizations about physical activity and sleep levels for female LEOs. Future research should include both male and female LEOs. Third, the number of days the subjects wore the accelerometers and sleep monitors was limited to 5 or fewer. Monitoring sleep and physical activity for a longer period of time may provide more stable estimates of these outcomes. Fourth, the lipid panel was not available for everyone who wore the sleep monitors and accelerometers, thus limiting our ability to statistically compare all subjects for these variables.

The sedentary nature of law enforcement and challenges associated with working night shift makes law enforcement a unique profession and places officers at an increased risk for developing CAD and metabolic syndrome. Our study showed that LEO's need to perform more physical activity during leisure time and on work days. Additionally, LEO's working the second and third shifts need to sleep more. Suggestions to improve these outcomes include physical examinations to assess cardiovascular and metabolic syndrome risk factors, mandatory exercise time while on-duty, annual physical activity assessments, sleep seminars, and screenings for sleep disorders. Future research is needed

to determine whether physical activity and sleep screening and treatment programs in a law enforcement setting will reduce these risks.

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VITA

The author, Nicole Christina Koebke, was born in Silver Spring, MD on October 31, 1986. She attended the University of Maryland, College Park from 2005 to 2008 and received a Bachelor of Science in Kinesiology in 2008. She began work toward a Master of Science in Exercise Physiology at the University of Kentucky in the Fall of 2010.