IOWA STATE UNIVERSITY
Digital Repository

2011

Assessment of contributors to the metabolic syndrome among law enforcement officers

Hyelim Yoo
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/etd

 Part of the Kinesiology Commons

Assessment of contributors to the metabolic syndrome among law enforcement officers

by

Hyelim Yoo

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Kinesiology (Biological Basis of Physical Activity)

Program of Study Committee:
Warren D. Franke, Major Professor
Amy S. Welch
Marian L. Kohut
Annette M. O'Connor
W. Robert Stephenson

Iowa State University

Ames, Iowa

2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

It is a pleasure to thank the many people who made this thesis possible.

Foremost, I would like to express my sincere gratitude to my Ph.D. advisor, Professor Warren Franke, Ph.D., for his enthusiasm, patience, motivation, and for the continuous support of my Ph.D. study and research. Throughout my thesis-writing period, he provided encouragement, good guidance, good teaching, and lots of good ideas. In addition, he was always accessible when I got into trouble with my research. I would have been lost without him.

Besides my advisor, I am deeply grateful to the rest of my thesis committee: Professor Amy Welch, Ph.D., Professor Marian Kohut, Ph.D., Professor Annette O'Connor, Ph.D., and Professor W. Robert Stephenson, Ph.D., for their encouragement, detailed comments, and constant guidance. In particular, I would like to thank Professor W. Robert Stephenson for his thoughtful guidance and comments on matters relating to thesis data and statistical analysis.

I wish to thank Professor Greg Welk, Ph.D., who allowed me to join and involve in his research projects. The associated experience broadened my perspective and insight on the area of measurement of physical activity.

I am deeply indebted to many of my colleagues to provide me a fun, warm, and enjoyable environment throughout my Ph.D. work. I am especially grateful to Michelle Hall, Liz Hageman, Kira Werstein, and Kate Stafford for revising the English of my manuscript and being a great company.

I would like to thank the many people who brought me into the world of kinesiology and encouraged me to keep pursuing my study in this area: especially, Sang-

Il Lee, my high school physical education teacher and Hyeung-Reul Kim, Sang-Jik Lee, and Jin-Gi Park, my undergraduate teachers in Korea.

I wish to express my warm and sincere thanks to my best friends, Rayeong Lee and Miseon Hong, for their emotional support and caring they provided to help me get through the difficult times. They have always been my best counselors.

My deepest gratitude goes to my family for their endless love and support throughout my life. My parents, Seokchang Yoo and Geumsun Jeong, are my inspiration to keep me moving forward to reach my dreams and goals. Without their spiritual support, this thesis could not have been accomplished. I thank my brother, my sister-in-law, and my nephew for providing me heart warming wishes and words. I owe my loving thank to my wonderful husband Sumit Ranjan, for his faithful love, support, patient and encouragement during each stage of my Ph.D. work. Thank you for being there for me and making me laugh all the time.

Hyelim Yoo

Iowa State University

March 2011

CHAPTER 1

GENERAL INTRODUCTION

Introduction

The metabolic syndrome has received a great deal of attention in the last few years. It is characterized by a cluster of specific cardiovascular disease (CVD) risk factors, comprised of central obesity, elevated blood pressure, high triglycerides, reduced levels of high-density lipoprotein (HDL) cholesterol and elevated fasting glucose levels (1). The metabolic syndrome is a metabolic disorder that has increased dramatically over the last few decades (2). Based on data from the National Health and Nutrition Examination Survey (NHANES) III (1988-1994), approximately 24% of U.S. adults aged 20 years or older have the metabolic syndrome (2). This rate has since increased to 27% in NHANES 1999-2000 (2) and 34% in NHANES 2003-2006 (3). Epidemiological studies have been done extensively to determine the prevalence and associated risk factors of the metabolic syndrome in the general population, yet less attention has been paid to its prevalence and risk factors for specific occupational groups, such as law enforcement officers (LEOs).

Several studies have suggested that LEOs experience an increased risk for CVD morbidity and mortality compared with the general population (4-6). Since the metabolic syndrome is associated with an increased risk for CVD (7-9), one might expect LEOs to have an increased risk for developing the metabolic syndrome. However, limited data are available on the risk of the metabolic syndrome among police officers. According to the U.S. Bureau of Justice Statistics, over 880,000 police officers are employed in the United

States (10). Assessing the prevalence of the metabolic syndrome over time and identifying possible risk factors is critical to reduce CVD risk and further reduce the premature death among this occupational cohort.

LEOs have a higher prevalence of several cardiometabolic risk factors such as hypertension (6, 11), hypercholesterolemia (6, 11), obesity (6, 11), and diabetes (5) which increase the risk of the metabolic syndrome. Although there are several increased cardiometabolic risk factors found in LEOs, conventional CVD risk factors do not fully account for the increased risk of CVD seen in LEOs (6). Conventional CVD risk factors include hypertension, hypercholesterolemia, hyperglycemia, obesity, advancing age, tobacco use, and physical inactivity (12). Franke and coworkers (13) found that the 10-year risk of developing CVD based on conventional CVD risk factors in LEOs does not differ significantly from a cohort of the general population. Retired LEOs had a significantly higher incidence of CVD than the general public even after controlling for conventional CVD risk factors (5). Franke and colleagues (5) also showed that employment as a law enforcement officer was an independent risk factor for CVD with an odds ratio (OR) of 2.34 (95% confidence interval [95% CI] = 1.53 – 3.58). Consequently, these results suggest that the higher prevalence of CVD seen in LEO may not be fully explained by a higher prevalence of several traditional CVD risk factors. In other words, risk factors that were not accounted for or unique characteristics of this occupation may explain the association of an increased risk for CVD and LEOs.

The metabolic syndrome also has multiple acquired underlying risk factors such as obesity, weight gain, physical inactivity, and unhealthy diet (14, 15). Obesity is closely associated with an increased risk for the metabolic syndrome (2). Effective

weight reduction is known to improve individual components of the metabolic syndrome (16), whereas weight gain during adulthood is known to exacerbate individual components of the metabolic syndrome (17-19). Regular and sustained physical activity positively influences individual components of the metabolic syndrome, such as decreased body weight and visceral fat accumulation, decreased blood pressure, increased HDL cholesterol and decreased triglyceride levels, and improved insulin sensitivity (20-22).

Psychosocial stress may also play a role in the pathogenesis of the metabolic syndrome (23-26). Continuous exposure to work-related stress can alter autonomic nervous and neuroendocrine systems that control reactions to stress (23). The neuroendocrine responses from the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system stimulate stress-related cortisol secretion that contributes to the development of chronic diseases such as dyslipidemia, abdominal obesity, hypertension, and insulin resistance and further escalates CVD and the metabolic syndrome (25, 26).

Compared to other occupations, police work is considered as highly stressful (27, 28). However, there is no clear consensus of the association between stress and the metabolic risk among LEOs. Franke and coworkers (6) showed that perceived stress is associated with CVD prevalence in police officers (OR = 1.05, 95% CI = 1.00 – 1.10). However, Yoo and colleagues (29) found that there is no significant association between perceived stress and the metabolic syndrome in a LEO cohort. Due to the cross-sectional nature of the study design for both studies, it is not possible to discern the causal relationship between stress and the metabolic syndrome in LEOs.

Few studies have examined the metabolic syndrome in LEOs, although the risk of the metabolic syndrome in the law enforcement profession has been debated. Some studies suggest that LEOs have a higher prevalence of the metabolic syndrome than the general population (30-33), while others suggest that LEOs have a similar or even a lower prevalence of the metabolic syndrome compared to the general public (29, 34). However all these assessments are based on cross-sectional studies; the trends in the prevalence of the metabolic syndrome over time among LEOs are not available.

As a major risk factor for CVD and Type 2 diabetes (35), the metabolic syndrome has gained increased attention among the general public. However, to date, data on the metabolic syndrome prevalence and the association between the metabolic syndrome and acquired underlying risk factors in LEOs are limited. Even if the metabolic syndrome data in the LEO cohort are available, almost all studies have cross-sectional designs which do not allow to track trends of the metabolic syndrome risk nor discern causal relationships between risk factors and the metabolic syndrome in police officers. Therefore, the purpose of this line of research is two-fold: first, to examine associated risk factors for the metabolic syndrome such as physical inactivity, obesity, and weight gain; and second, to assess the prevalence of the metabolic syndrome and the effect of stress on the risk of the metabolic syndrome over time in this unique occupational cohort.

Dissertation Organization

The series of papers presented in this dissertation will provide a better understanding of the prevalence and risk factors of the metabolic syndrome among LEOs. To provide appropriate background for this research, an extended review of the literature is provided in Chapter 2. Chapters 3, 4, and 5 will be presented in manuscript form (i.e.,

abstract, introduction, methods, results, discussion, acknowledgements, and references).

Chapter 3 examines the independent and combined influence of physical activity and

obesity on the metabolic syndrome risk profile in LEOs. Chapter 4 examines the

association between weight gain and the metabolic syndrome in police officers. Chapter

5 examines the longitudinal analysis of police stress and the metabolic syndrome between

2001 and 2007. A summary of the findings herein is included in Chapter 6. Tables and

figures will appear at the end of each study.

References

1. Grundy SM, Brewer HB, Jr., Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109(3):433-8.

2. Ford E, Giles W, Mokdad A. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care* 2004;27(10):2444-9.

3. Ervin R. 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. *Natl Health Stat Report* 2009(13):1-7.

4. Calvert G, Merling J, Burnett C. Ischemic heart disease mortality and occupation among 16- to 60-year-old males. *J Occup Environ Med* 1999;41(11):960-6.

5. Franke WD, Collins SA, Hinz PN. Cardiovascular disease morbidity in an Iowa law enforcement cohort, compared with the general Iowa population. *J Occup Environ Med* 1998;40(5):441-4.

6. Franke WD, Ramey SL, Shelley MC. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *J Occup Environ Med* 2002;44(12):1182-9.

7. Lakka HM, Laaksonen DE, Lakka TA, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;288(21):2709-16.

8. Ford E. The metabolic syndrome and mortality from cardiovascular disease and all-causes: findings from the National Health and Nutrition Examination Survey II Mortality Study. *Atherosclerosis* 2004;173(2):309-14.

9.   Malik S, Wong N, Franklin S, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation* 2004;110(10):1245-50.

10.   Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2010-11 Edition*, Police and Detectives, on the Internet at http://www.bls.gov/oco/ocos160.htm.

11.   Balkau B, Shipley M, Jarrett R, et al. High blood glucose concentration is a risk factor for mortality in middle-aged nondiabetic men. 20-year follow-up in the Whitehall Study, the Paris Prospective Study, and the Helsinki Policemen Study. *Diabetes Care* 1998;21(3):360-7.

12.   American Heart Association (2005). Heart Disease and Stroke Statistics - 2005 Update. American Heart Association.

13.   Franke W, Cox D, Schultz D, et al. Coronary heart disease risk factors in employees of Iowa's Department of Public Safety compared to a cohort of the general population. *Am J Ind Med* 1997;31(6):733-7.

14.   Eckel R, Grundy S, Zimmet P. The metabolic syndrome. *Lancet* 2005;365(9468):1415-28.

15.   Carnethon M, Loria C, Hill J, et al. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985-2001. *Diabetes Care* 2004;27(11):2707-15.

16.   Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res* 1998;6 Suppl 2:51S-209S.

17.   Black E, Holst C, Astrup A, et al. Long-term influences of body-weight changes, independent of the attained weight, on risk of impaired glucose tolerance and Type 2 diabetes. *Diabet Med* 2005;22(9):1199-205.

18.   Sonne-Holm S, Sørensen T, Jensen G, et al. Independent effects of weight change and attained body weight on prevalence of arterial hypertension in obese and non-obese men. *BMJ* 1989;299(6702):767-70.

19.   Truesdale K, Stevens J, Lewis C, et al. Changes in risk factors for cardiovascular disease by baseline weight status in young adults who maintain or gain weight over 15 years: the CARDIA study. *Int J Obes (Lond)* 2006;30(9):1397-407.

20.   Katzmarzyk P, Leon A, Wilmore J, et al. Targeting the metabolic syndrome with exercise: evidence from the HERITAGE Family Study. *Med Sci Sports Exerc* 2003;35(10):1703-9.

21. Rice B, Janssen I, Hudson R, et al. Effects of aerobic or resistance exercise and/or diet on glucose tolerance and plasma insulin levels in obese men. *Diabetes Care* 1999;22(5):684-91.

22. Lakka T, Laaksonen D, Lakka H, et al. Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Med Sci Sports Exerc* 2003;35(8):1279-86.

23. Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. *BMJ* 2006;332(7540):521-5.

24. Steptoe A, Brunner E, Marmot M. Stress-induced inflammatory responses and risk of the metabolic syndrome: a longitudinal analysis. *Obes Res* 2004;12:A76.

25. Björntorp P, Rosmond R. Hypothalamic origin of the metabolic syndrome X. *Ann N Y Acad Sci* 1999;892:297-307.

26. Rosmond R, Björntorp P. The hypothalamic-pituitary-adrenal axis activity as a predictor of cardiovascular disease, type 2 diabetes and stroke. *J Intern Med* 2000;247(2):188-97.

27. Gershon RR, Lin S, Li X. Work stress in aging police officers. *J Occup Environ Med* 2002;44(2):160-7.

28. Kop N, Euwema MC. Occupational stress and the use of force by Dutch police officers. *Criminal Justice and Behaviour* 2001;28:631-52.

29. Yoo HL, Eisenmann JC, Franke WD. Independent and Combined Influence of Physical Activity and Perceived Stress on the Metabolic Syndrome in Male Law Enforcement Officers. *J Occup Environ Med* 2009;51(1):46-53.

30. Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

31. Chandramohan P, Mohan V. High prevalence of diabetes and metabolic syndrome among policemen. *J Assoc Physicians India* 2008;56:837-9.

32. Humbarger C, Crouse S, Womack J, et al. Frequency of metabolic syndrome in police officers compared to NCEP III prevalence values. *Med Sci Sports Exerc* 2004;36(5):S161.

33. Bos M, de Vries J, Wolffenbuttel B, et al. The prevalence of the metabolic syndrome in the Netherlands: increased risk of cardiovascular diseases and diabetes mellitus type 2 in one quarter of persons under 60. *Ned Tijdschr Geneeskd* 2007;151(43):2382-8.

34.   Violanti J, Fekedulegn D, Hartley T, et al. Police trauma and cardiovascular disease: association between PTSD symptoms and metabolic syndrome. *Int J Emerg Ment Health* 2006;8(4):227-37.

35.   Wannamethee S, Shaper A, Lennon L, et al. Metabolic syndrome vs Framingham Risk Score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Arch Intern Med* 2005;165(22):2644-50.

CHAPTER 2

LITERATURE REVIEW

Introduction

In the past few years, growing attention has been paid to the metabolic syndrome. The prevalence of the metabolic syndrome has been rising dramatically over recent decades and has become a major public challenge worldwide (1, 2). The metabolic syndrome increases the risk for cardiovascular disease (CVD) (3, 4). Although previous studies have shown that law enforcement officers (LEOs) have higher CVD prevalence than the general public (5, 6), less attention has been paid to the relationship between the metabolic syndrome and LEOs. Therefore, the purpose of this literature review is to present previous studies on the metabolic syndrome in LEOs. This review will also include current definitions, the prevalence of the metabolic syndrome among the general public and its major risk factors including stress, obesity, weight gain, and physical inactivity, within LEOs.

The Metabolic Syndrome

The metabolic syndrome is now a widely diagnosed medial disorder characterized by a cluster of abnormalities that come together in a single individual. The metabolic risk components include central obesity, elevated blood pressure, high triglycerides, reduced levels of high-density lipoprotein (HDL) cholesterol and elevated fasting glucose plasma levels (7, 8). The presence of the metabolic syndrome is recognized as a significant predictor of coronary heart disease, stroke, and Type 2 diabetes mellitus (3). Wannamethee and colleagues (9) showed that the metabolic syndrome is significantly

associated with an increased risk of coronary heart disease (relative risk [RR] = 1.57,

95% confidence interval [CI] = 1.39 – 1.97), stroke (RR = 1.61, 95% CI = 1.26 – 2.06)

and type 2 diabetes (RR = 3.57, 95% CI = 2.83 – 4.50) in middle-aged men. The

Atherosclerosis Risk in Communities study examined the association between the

metabolic syndrome and CVD morbidity over a mean of 11 years (10). This study found

that men and women with the metabolic syndrome were approximately 1.5 (95% CI =

1.23 – 1.74) and 2 (95% CI = 1.59 – 2.64) times more likely to develop coronary heart

disease than those without the metabolic syndrome after controlling for age, smoking,

low-density lipoprotein (LDL) cholesterol, and race. The metabolic syndrome is also

associated with higher CVD mortality. Lakka and coworkers (11) showed that over a

mean of 11.4 years of follow-up, men with the metabolic syndrome were 2.9 (95% CI =

1.2 – 7.2) to 4.2 (95% CI = 1.6 – 10.8) times more likely to die of coronary heart disease

after adjustment for conventional cardiovascular risk factors.

Although the term 'metabolic syndrome' was coined and defined in the 1980s, the

criteria for diagnosis of the metabolic syndrome have not been accepted universally (12).

Its definition and diagnostic criteria are slightly different depending on which

organization's definition is used. Definitions of the metabolic syndrome have been

provided by the World Health Organization (WHO) in 1999 (13) , the European Group

for the Study of Insulin Resistance in 1999 (14), the National Heart, Lung, and Blood

Institute acting through the National Cholesterol Education Program Adults Treatment

Panel III (NCEP-ATP III) in 2001 (8), and the International Diabetes Federation (IDF) in

2006 (15). The American Heart Association (AHA) in conjunction with the National

Heart, Lung and Blood Institute (NHLBI) revised the NCEP-ATP III definition in 2006 (16).

The NCEP-ATP III, IDF and AHA/NHLBI statements are three major definitions commonly used in the literature. Based on the NCEP-ATP III definition, adult metabolic syndrome is defined as the presence of three or more of the following five abnormalities: (1) abdominal obesity (waist circumference >102 cm for men and >88 cm for women); (2) raised triglycerides ($\geq$150 mg/dL (1.69 mmol/L)); (3) reduced HDL cholesterol (<40 mg/dL (1.04 mmol/L) for men and <50 mg/dL (1.29 mmol/L) for women); (4) raised blood pressure (a systolic blood pressure $\geq$130 mmHg or a diastolic blood pressure $\geq$85 mmHg); and (5) raised fasting glucose ($\geq$110mg/dL (6.1 mmol/L) or previous diagnosis with type 2 diabetes). In 2006, the IDF proposed a new worldwide definition of the metabolic syndrome. According to the IDF definition, a person with the metabolic syndrome must have central obesity (defined as waist circumference with ethnicity specific values) in addition to any two of the following: (1) elevated blood pressure (a systolic blood pressure $\geq$130 mmHg or a diastolic blood pressure $\geq$85 mmHg, or treatment of previously diagnosed hypertension; (2) elevated fasting plasma glucose ($\geq$100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes); (3) elevated triglycerides ($\geq$150 mg/dL (1.7 mmol/L), or specific treatment for this lipid abnormality); and (4) reduced HDL cholesterol (men: <40 mg/dL (1.03 mmol/L); women:<50 mg/dL (1.29 mmol/L), or specific treatment for this lipid abnormality). Changes in the AHA/NHLBI statement are only minor to the NCEP-ATP III definition. The AHA/NHLBI definition uses the lower threshold for elevated fasting glucose as used by in the IDF definition. The AHA/NHLBI criteria for the definition of the metabolic

syndrome includes the presence of at least three of the following abnormalities: (1)

elevated central obesity (waist circumference $\geq$102 cm for men and $\geq$88 cm for females);

(2) elevated blood pressure ($\geq$130 mmHg in systolic or $\geq$85 mmHg in diastolic blood

pressure, or taking medication for hypertension); (3) elevated fasting glucose: $\geq$100

mg/dL (5.6 mmol/L) or taking medication for hyperglycemia; (4) elevated triglycerides

($\geq$150 mg/dL); and (5) reduced HDL cholesterol (< 40 mg/dL for men and <50 mg/dL for

women). All three definitions used by the NCEP-ATP III, IDF, and AHA/NHLBI have

similar criteria to identify the metabolic syndrome and it can be expected that the

majority of people identified as having the metabolic syndrome based on one definition

will also be identified as having the metabolic syndrome based on other definitions.

However, there are two major differences between the AHA/NHLBI and IDF definitions

in central obesity criteria, although both definitions use waist circumference to assess

abdominal obesity. First, the IDF uses different waist circumference cut-points for

abdominal obesity depending on geography, whereas the AHA/NHLBI does not consider

geographical differences in abdominal obesity and applies only one cut-point for waist

circumference. Secondly, the IDF definition states that, if body mass index (BMI) is

greater than 30 kg/m^2, waist circumference does not need to be measured since central

obesity can be assumed. BMI is a viable surrogate to classify those with the metabolic

syndrome (17).

Despite slight variations in how the metabolic syndrome is defined amongst

various research groups, the prevalence of the metabolic syndrome among U.S. adults

continues to rise. Based on data from the Third National Health and Nutrition

Examination Survey (NHANES III) 1988 - 1994, the age-adjusted prevalence of the

metabolic syndrome among U.S. adults (aged 20 years or over) was approximately 24% (18). This rate has since increased to 27% in NHANES 1999-2000 (1) and 34% in NHANES 2003-2006 (19).

Associated Risk Factors for the Metabolic Syndrome in Law Enforcement Officers

The metabolic syndrome, a cluster of cardiometabolic risk factors including central obesity, dyslipidemia, hypertension, and glucose intolerance (7), is associated with an increased risk for CVD (20). Since a significant portion of the general population has several conventional CVD risk factors such as hypertension, hypercholesterolemia, obesity, and diabetes (21), LEOs also have an increased prevalence of these risk factors (5, 22, 23). However, conventional risk factors do not fully explain the increase in CVD seen in LEOs, thus nor probably in the metabolic syndrome. The 10-year risk for developing CVD using conventional CVD risk factors in LEOs did not significantly differ from a reference population when assessed either longitudinally or cross-sectionally (24). Furthermore, retired LEOs have up to a 1.7 times higher prevalence of CVD than the general population of similar age even after controlling for conventional risk factors (5). Therefore, risk factors that were not accounted for or unique characteristics of this occupation of law enforcement, rather than conventional risk factors, may explain an increased risk for CVD seen in LEOs. The metabolic syndrome may play a role in this risk.

Possible risk factors for high prevalence rates of the metabolic syndrome among LEOs may include poor physical activity and work stress (25). Obesity and weight gain

are also considered important risk factors for the metabolic syndrome (26). Thus, this section of the literature review includes reviews of each proposed risk factor associated with the metabolic syndrome. Numerous papers and reviews have been published describing each of these possible risk factors of the metabolic syndrome. Hence, the focus within is to provide a relatively brief overview of these risk factors and how each is related to the metabolic syndrome.

Stress and the Relationship to the Metabolic Syndrome

Stress is defined as a state in which harmony or homeostasis is actually threatened or perceived to be so, evoked by various cognitive (e.g., anxiety, fear, depression) and/or somatic stressors (e.g., pain, lipid accumulation, inflammation) when the threat to homeostasis exceeds the threshold (27).

Policing is perceived as a highly stressful occupation (28, 29). It is recognized as one of the most stressful occupations in the world (30). By the nature of their jobs, many police officers face considerable work-related stressors on a daily basis from critical incident stress (e.g., emotional stress after facing a specific incident or incidents) to organizational work stressors (e.g., duties unrelated to field work). Critical incidents have a significant effect on perceived work-related stress in LEOs, although the effects are generally acute (31). However, stressors from organizational work rather than police work *per se* are recognized as the most harmful stressors in law enforcement occupation (32, 33). Work environment and work-related stressors are major factors in chronic organizational stress in policing (34). Perceived stress, which measures the degree to which a person appraises situations in his or her life as stressful, is one of several psychosocial factors related to work-related stress (35).

Perceived work stress has been linked with CVD (36-38) as well as components of the metabolic syndrome (39-43). Franke and colleagues (22) found that higher levels of perceived stress are directly associated with increased CVD prevalence, in addition to increased prevalences of hypercholesterolemia, hypertension, and physical inactivity, in LEOs. Recent studies also suggest that stress at work may influence the pathogenesis of the metabolic syndrome (42, 44, 45). Chandola and coworkers (44) conducted a prospective cohort study with an average of 14 years of follow-up on 10,308 men and women. This study found that employees with chronic work stress are more than twice as likely to have the metabolic syndrome than those without stress at work, after controlling for age and employment grade (odd ratio [OR] = 2.25, 95% CI = 1.31 – 3.85).

Although biological mechanisms of this relationship remain unclear, prolonged exposure to work stress may affect the autonomic nervous system and neuroendocrine responses that can contribute to the development of the metabolic syndrome (44). Neuroendocrine responses to stress activate the hypothalamic-pituitary-adrenal (HPA) axis, resulting in the secretion of steroid hormones, including corticosteroids and catecholamines, which are major stress hormones (46). Cortisol is a corticosteroid hormone which is secreted from the adrenal cortex under the control of the HPA axis (46). During short-term acute stress, plasma cortisol levels are elevated by the activation of the HPA axis for survival through homeostatic adjustments (47). However, frequent chronic stress may sustain elevated cortisol secretion that may damage to the HPA axis with time, resulting in a maladaptive process (48, 49). Stress-related cortisol secretion has been linked with individual components of the metabolic syndrome. For example, stress-dependent cortisol values are strongly associated with abdominal obesity, glucose,

triglycerides, HDL cholesterol, and systolic and diastolic blood pressure (39, 42, 43).

Therefore, chronic stress at work is an important risk factor for the metabolic syndrome.

Obesity and the Relationship to the Metabolic Syndrome

Obesity is a chronic condition characterized by the presence of abnormal or

excessive body fat. It is one of the most serious public health problems facing the U.S.

population contributing to approximately 280,000 deaths annually (50). Obesity also

increases the chance of various chronic diseases, including cardiovascular disease, stroke,

Type 2 diabetes, and some types of cancer (51). At an individual level, excessive body

fat results from an imbalance between energy intake and energy expenditure in which

energy intake exceeds energy expenditure (52).

A number of techniques measure obesity, such as BMI, waist circumference,

waist-to-hip ratio, and skin-fold thickness. Throughout the current epidemiological

literature, BMI is the most commonly used method to assess obesity. BMI is a ratio of

weight to height calculated by dividing a person's body weight in kilograms by their

height in meters squared (kg/m^2). For adults, overweight and obesity are defined as a

BMI of 25 kg/m^2 to 29.9 kg/m^2 and 30 kg/m^2 or higher, respectively (53).

Obesity is recognized as a global epidemic (54). The rate of obesity has climbed

dramatically, with the prevalence doubling amongst U.S. adults between 1980 and 2002

(55). Based on data from the NHANES, the prevalence of obesity was 30.5% in 1999-

2000 and 32.2% in 2003-2004 (56) compared with 22.9% in 1988-1994 among U.S.

adults (55). If both overweight and obesity are considered, the prevalence increased from

55.9% in 1988-1994 (55) to 66.3% in 2003-2004 (56) among U.S. adults.

Obesity may be more prevalent in police officers compared to the general public. LEOs have greater prevalence of increased BMI (over 25 kg/m^2) compared to similarly-aged general population with similar incomes (82.6% vs. 70.9%, P <0.0001) (22). Overweight (BMI >27 kg/m^2) is more prevalent in LEOs compared with the general public of similar age (55.2% vs. 34.8%, P <0.001) (5). The prevalence of abdominal obesity and increased BMI are higher among LEOs than the general population (65.1% vs. 32.7%, P <0.001 and 62.9% vs. 35.4%, P <0.001, respectively) (57). Furthermore, police officers tend to be leaner than similarly aged non-officers when they are younger (i.e., ≤48 years), but they appear to get fatter faster over time, such that they are fatter than their peers when they are older (i.e., >48 years) (58).

The odds of having metabolic syndrome increase with increasing levels of BMI in men and women (59). The metabolic syndrome was found in 4.6%, 22.4%, and 59.6% of normal weight, overweight, and obese men, respectively, and in 6.2%, 28.1%, and 50.0% of normal weight, overweight, and obese women, respectively based on the NHANES III (59). Thus, most individuals with the metabolic syndrome are overweight or obese, which suggest that obesity in conjunction with genetic aspects of susceptibility may link the components of the metabolic syndrome (60). In the presence of obesity and excess visceral fat, multiple products such as non-esterified fatty acids (NEFA) released from adipocytes are produced in abnormal amounts (61). Increased amounts of NEFA into muscle, observed among obese individuals, contribute to insulin resistance (62, 63). An excessive influx of NEFA into the liver increases the triglyceride content of the liver (64). Increased fat in the liver produces insulin resistance as well as atherogenic dyslipidemia, resulting in high serum triglycerides and reduced HDL cholesterol

concentrations (61). High NEFA levels may contribute to higher blood pressure also (65). Therefore, obesity is likely to be an underlying risk factor for the metabolic syndrome by raising the risk through individual components including hypercholesterolemia, hypertension, hyperglycemia, and insulin resistance.

Weight Gain and the Relationship to the Metabolic Syndrome

Recent studies have found a high prevalence of metabolically healthy overweight and obese individuals and a high prevalence of clustering of cardiometabolic abnormalities among normal-weight individuals (66, 67). The variability in cardiomatebolic risk observed among individuals of similar BMI group has turned researchers' attention from BMI or current weight to weight history.

The mean body weight of U. S. adult men and women (aged 20 – 74 years) increased by 0.24 kg per year (68), while the mean body weight of police officer increased 0.48 kg per year (69). Sedentary occupations with high levels of sitting time and lower demand for physical activity have been associated with weight gain and obesity (70, 71). The police occupation requires occasional physical demands but mostly involves sedentary tasks (69). Thus, work environment in the police occupation may greatly influence the growing problem of weight gain and obesity.

Previous studies suggest that weight history can independently impact disease factors. Weight gain since 20 years of age is associated with an increased risk of developing impaired glucose tolerance, independent of attained body weight in middle-aged men (OR = 1.10 per unit kg/m^2 of BMI gain, 95% CI = 1.03 – 1.17) (72). Men with a history of weight gain have a higher risk of hypertension than those with a stable weight history, independent of attained level of body weight (73). Among middle-aged women

within the BMI range of 18 to 25 kg/m^2, weight gain after 18 years of age has been

associated with increased risk of coronary heart disease (74). Among adults aged 50 – 64

years, individuals experiencing weight gain during the previous 10 to 15 years of the

current age have a higher risk of having the metabolic syndrome compared to those with

stable body weight, independent of current BMI (OR = 1.89, 95% CI = 1.19 – 3.01) (75).

Weight gain of as little as 2.25 kg over a 4-year period is linked to worsening health

status such as decreased physical function and vitality, and increased bodily pain,

independent of baseline weight (76). Over a 14 year period, coronary heart disease risk

increases with an increased amount of weight gain; RR = 1.25 (95% CI = 1.01 – 1.55) for

a 5- to 7.9-kg gain, 1.64 (1.33 – 2.04) for an 8- to 10.9-kg gain, 1.92 (1.61 – 2.29) for an

11- to 19-kg gain, and 2.65 (2.17 – 3.22) for a gain of 20 kg or more (74). The metabolic

syndrome risk increases 23% per 4.5 kg of weight gained over 15 years (RR = 1.23, 95%

CI = 1.20 – 1.27) (26). Hence, weight gain is an important risk factor for the metabolic

syndrome.

Physical Activity and the Relationship to the Metabolic Syndrome

Physical activity has been defined as any bodily movement produced by skeletal

muscles that result in energy expenditure beyond resting expenditure (77). Many

previous studies have demonstrated that physical activity is associated with reduced risk

of the metabolic syndrome (78-82), and physical inactivity may be an important

modifiable risk factor in the etiology of the metabolic syndrome (83, 84). While the

metabolic syndrome has increased in the past few decades, the amount of physical

activity energy expenditure has declined during this time (85). Thus, individuals with a

lack of physical activity may be at risk of the metabolic syndrome. Tharkar and

colleagues (57) observed a lack of physical activity and an abundance of sedentary life style among police officers when compared to the general population. LEOs either sit or stand for long hours and walk less compared to the general public (57). In addition, physical activity involvement and physical demands during active duty police work are usually limited and insufficient to maintain physical fitness (86). Yoo and colleagues (87) found that low (<30 minutes of physical activity of any kind per week) and moderate levels of physical activity ($\geq$30 to <60 minutes of mild-to-moderate-intensity physical activity per week) are associated with more than 3- and 2- fold higher odds for having the metabolic syndrome than high levels of physical activity ($\geq$60 minutes of vigorous physical activity or $\geq$150 minutes of moderate physical activity per week) among LEOs (OR = 3.13, 95% CI = 1.56 – 6.26 and OR = 2.30, 95% CI = 1.29 – 4.09, respectively). Hence, physical inactivity may be an important risk factor for the metabolic syndrome in LEOs.

Physical activity protects against the metabolic syndrome itself and the components of the metabolic syndrome. Rennie and colleagues (78) showed that increasing moderate (MET $\geq$3 to 5, including activities such as walking and gardening) and vigorous (MET $\geq$5, including activities such as cycling and swimming) leisure-time physical activity are each associated with reduced odds of the metabolic syndrome after controlling for age, sex, smoking, alcohol intake, socioeconomic status, and other activity (OR = 0.78, 95% CI = 0.63 – 0.96 and OR = 0.52, 95% CI = 0.40 – 0.67, respectively) in middle-aged populations. Laaksonen and coworkers (80) found that men engaging in > 180 minutes per week of moderate or vigorous leisure-time physical activity (MET $\geq$ 4.5) are almost half as likely to develop the metabolic syndrome than sedentary men who

engage ≤60 minutes of moderate or vigorous intensity exercise per week (OR = 0.52, 95% CI = 0.30 – 0.90) after adjustment for age, BMI, adult socioeconomic status, presence of CVD, smoking, and alcohol consumption. In intervention studies, physical activity is, in variable degrees, an effective means of reducing weight and visceral fat accumulation (88-90), lowering blood pressure (91), increasing HDL cholesterol and decreasing triglycerides (92, 93), and improving insulin sensitivity (89, 90).

Physical activity energy expenditure, independent of aerobic fitness, may predict development of the metabolic syndrome. Ekelund and colleagues (94) examined the prospective associations between objectively measured physical activity energy expenditure, aerobic fitness, and the progression toward the metabolic syndrome in 605 middle aged men and women who were free of the metabolic syndrome at baseline over a 5.6-year follow-up period. The measure of physical activity in this study was based on the amount of energy expenditure above resting levels, including all types and intensities of activity performed in daily life. Physical activity energy expenditure predicted progression toward the metabolic syndrome over a 5.6-year period, independent of aerobic fitness and other potential confounding factors (standardized β = -0.00085, P = 0.046). The results also suggested that aerobic fitness (e.g., VO_{2max}) is not an independent predictor of the metabolic syndrome after controlling for physical activity.

Physical inactivity and sedentary behavior are each associated with an increased risk for the metabolic syndrome. Individuals who do not engage in any moderate or vigorous leisure-time physical activity are almost twice as likely to have the metabolic syndrome (OR = 1.90, 95% CI = 1.22 – 2.97) than those who engage in ≥150 minutes per week of such activity although this association became non-significant after adjustment

for age, sex, race or ethnicity, educational status, smoking status, and alcohol use (OR =

1.46, 95% CI = 0.87 – 2.45) (79). Compared with individuals who engaged in sedentary

behaviors such as viewing television, videos, or working on a computer <1 hour per day

outside of work, those who engaged in sedentary behaviors ≥4 hours per day have an

increased risk for having the metabolic syndrome after controlling for age, sex, race or

ethnicity, educational status, smoking status, and alcohol use (OR = 2.10, 95% CI = 1.27

– 3.47) (79).

Therefore, physical inactivity is an important risk factor for the metabolic

syndrome, and physical activity even without improvement in aerobic fitness is protective

of the metabolic syndrome.

The Metabolic Syndrome in Law Enforcement Officers

Few studies have examined the metabolic syndrome in LEOs. Indeed, the risk of

the metabolic syndrome in the law enforcement profession has been debated. Evidence

suggests that LEOs have higher prevalence of the metabolic syndrome compared to the

general population. Humbarger and colleagues (95) found that the prevalence of the

metabolic syndrome among 84 U.S. male police officers was 27.4%, higher than the

predicted prevalence for the U.S. adult males (24.6%) (1). Tharka and coworkers (57)

showed that the prevalence of the metabolic syndrome among Indian male police officers

(n = 318) was significantly higher than their age-matched general Indian male population

(n = 401) (57.3 vs. 28.2%, χ^2 = 64.5, P <0.0001). Within the same cohort, the prevalence

of abdominal obesity, increased triglycerides levels, and blood pressure were

significantly higher compared to the general population (P <0.05 for all). The prevalence

of the metabolic syndrome among 874 Netherlander policemen was 22.5% (96), higher

than that of the national average among Netherlander men (16%) (97). These results

suggest that LEOs may be at higher risk of developing the metabolic syndrome.

Alternatively, however, studies suggest U.S. LEOs have a similar or even a lower

prevalence of the metabolic syndrome when compared with the general public. Violanti

et al. (98) found that approximately 16% of 101 LEOs (61 males and 40 females) were

defined as having the metabolic syndrome. This prevalence is somewhat lower than that

of the U.S. general population. Based on data from the NHANES III 1988-1994, the age-

adjusted prevalence rate of the metabolic syndrome among U.S. adults (aged 20 years or

over) was 24.1% (1). Nevertheless, when only people aged 30 to 39 in the NHANES

data were considered, the metabolic syndrome prevalence rate was 13%, similar to the

age group in the police sample of Violanti's study (98). Yoo et al. (87) observed that the

metabolic syndrome was present in 23.1% of 386 white male LEOs, slightly lower than

that of the U.S. general white male population (24.8%) (18). The police sample in this

study included individuals aged between 20 and 60 years; however, the NHANES data

included many individuals over 60 years. The prevalence rate of the metabolic syndrome

increases with increasing age (1); thus, the prevalence of the metabolic syndrome among

the police population in the study by Yoo et al. may be altered considering that effect of

age.

Collectively, these findings suggest there may be an increased risk for the

metabolic syndrome in LEOs compared to the general population. However all these

assessments are based on cross-sectional studies; the trends in the prevalence of the

metabolic syndrome over time among LEOs (i.e., longitudinal changes) are not available.

Summary

The metabolic syndrome is receiving increased attention, and important risk factors of the metabolic syndrome have been extensively examined in the general public. Police officers may be at increased risk of the metabolic syndrome. However, to date, data on its prevalence and the underlying risk factors in LEOs are very limited. Moreover, almost all the relevant studies have cross-sectional designs. The cross-sectional nature permits neither tracking trends of metabolic syndrome risk over time nor discerning causal relationships between risk factors and the metabolic syndrome in police officers. To reduce CVD risk and prevent further premature death from chronic diseases in police officers, there is a marked need for research including longitudinal data and studies on the prevalence and risk factors of the metabolic syndrome among this unique occupational cohort.

References

1. Ford E, Giles W, Mokdad A. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care* 2004;27(10):2444-9.

2. Yach D, Hawkes C, Gould C, et al. The global burden of chronic diseases: overcoming impediments to prevention and control. *JAMA* 2004;291(21):2616-22.

3. Wannamethee S, Shaper A, Lennon L, et al. Metabolic syndrome vs Framingham Risk Score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Arch Intern Med* 2005;165(22):2644-50.

4. Bonora E. The metabolic syndrome and cardiovascular disease. *Ann Med* 2006;38(1):64-80.

5. Franke WD, Collins SA, Hinz PN. Cardiovascular disease morbidity in an Iowa law enforcement cohort, compared with the general Iowa population. *J Occup Environ Med* 1998;40(5):441-4.

6.   Calvert G, Merling J, Burnett C. Ischemic heart disease mortality and occupation among 16- to 60-year-old males. *J Occup Environ Med* 1999;41(11):960-6.

7.   Grundy SM, Brewer HB, Jr., Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109(3):433-8.

8.   Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 2001;285(19):2486-97.

9.   Wannamethee S. The metabolic syndrome and cardiovascular risk in the British Regional Heart Study. *Int J Obes (Lond)* 2008;32 Suppl 2:S25-9.

10.   McNeill A, Rosamond W, Girman C, et al. The metabolic syndrome and 11-year risk of incident cardiovascular disease in the atherosclerosis risk in communities study. *Diabetes Care* 2005;28(2):385-90.

11.   Lakka HM, Laaksonen DE, Lakka TA, et al. The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 2002;288(21):2709-16.

12.   Liese A, Mayer-Davis E, Haffner S. Development of the multiple metabolic syndrome: an epidemiologic perspective. *Epidemiol Rev* 1998;20(2):157-72.

13.   Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications. Report of a WHO Consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus. Geneva: World Health Organization, 1999(WHO/NCD/NCS99.2).

14.   Balkau B, Charles M. Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabet Med* 1999;16(5):442-3.

15.   Alberti K, Zimmet P, Shaw J. Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* 2006;23(5):469-80.

16.   Grundy S, Cleeman J, Daniels S, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. *Curr Opin Cardiol* 2006;21(1):1-6.

17.   Malik S, Wong N, Franklin S, et al. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, and all causes in United States adults. *Circulation* 2004;110(10):1245-50.

18. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. *JAMA* 2002;287(3):356-9.

19. Ervin R. 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. *Natl Health Stat Report* 2009(13):1-7.

20. Zhang Y, Hong J, Gu W, et al. Impact of the metabolic syndrome and its individual components on risk and severity of coronary heart disease. *Endocrine* 2009;36(2):233-8.

21. American Heart Association (2005). Heart Disease and Stroke Statistics - 2005 Update. American Heart Association.

22. Franke WD, Ramey SL, Shelley MC. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *J Occup Environ Med* 2002;44(12):1182-9.

23. Balkau B, Shipley M, Jarrett R, et al. High blood glucose concentration is a risk factor for mortality in middle-aged nondiabetic men. 20-year follow-up in the Whitehall Study, the Paris Prospective Study, and the Helsinki Policemen Study. *Diabetes Care* 1998;21(3):360-7.

24. Franke W, Cox D, Schultz D, et al. Coronary heart disease risk factors in employees of Iowa's Department of Public Safety compared to a cohort of the general population. *Am J Ind Med* 1997;31(6):733-7.

25. Chandramohan P, Mohan V. High prevalence of diabetes and metabolic syndrome among policemen. *J Assoc Physicians India* 2008;56:837-9.

26. Carnethon M, Loria C, Hill J, et al. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985-2001. *Diabetes Care* 2004;27(11):2707-15.

27. Chrousos G, Gold P. The concepts of stress and stress system disorders. Overview of physical and behavioral homeostasis. *JAMA* 1992;267(9):1244-52.

28. Gershon RR, Lin S, Li X. Work stress in aging police officers. *J Occup Environ Med* 2002;44(2):160-7.

29. Kop N, Euwema MC. Occupational stress and the use of force by Dutch police officers. *Criminal Justice and Behaviour* 2001;28:631-52.

30. Selye H. Police stress. *Police Stress Magazine* 1984;1:2-5.

31. Violanti JM, Aron F. Ranking police stressors. *Psychol Rep* 1994;75(2):824-6.

32.   Abdollahi M. Understanding police stress. *Journal of Forensic Psychology Practice* 2002;2:1-24.

33.   Brown J, Campbell E. Sources of occupational stress in the police. *Work and Stress* 1990;4:305-18.

34.   Stinchcomb J. Searching for stress in all the wrong places: combating chronic organizational stressors in Policing *Police Practice and Research* 2004;5(3):259-77.

35.   Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24(4):385-96.

36.   Rosengren A, Hawken S, Ounpuu S, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364(9438):953-62.

37.   Marmot M, Bosma H, Hemingway H, et al. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 1997;350(9073):235-9.

38.   Peter R, Siegrist J. Chronic psychosocial stress at work and cardiovascular disease: the role of effort-reward imbalance. *Int J Law Psychiatry* 1999;22(5-6):441-9.

39.   Rosmond R, Björntorp P. The hypothalamic-pituitary-adrenal axis activity as a predictor of cardiovascular disease, type 2 diabetes and stroke. *J Intern Med* 2000;247(2):188-97.

40.   Siegrist J, Peter R, Cremer P, et al. Chronic work stress is associated with atherogenic lipids and elevated fibrinogen in middle-aged men. *J Intern Med* 1997;242(2):149-56.

41.   Peter R, Alfredsson L, Hammar N, et al. High effort, low reward, and cardiovascular risk factors in employed Swedish men and women: baseline results from the WOLF Study. *J Epidemiol Community Health* 1998;52(9):540-7.

42.   Rosmond R, Dallman M, Björntorp P. Stress-related cortisol secretion in men: relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. *J Clin Endocrinol Metab* 1998;83(6):1853-9.

43.   Björntorp P, Rosmond R. Hypothalamic origin of the metabolic syndrome X. *Ann N Y Acad Sci* 1999;892:297-307.

44.   Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. *BMJ* 2006;332(7540):521-5.

45.   Steptoe A, Brunner E, Marmot M. Stress-induced inflammatory responses and risk of the metabolic syndrome: a longitudinal analysis. *Obes Res* 2004;12:A76.

46.   Black P, Garbutt L. Stress, inflammation and cardiovascular disease. *J Psychosom Res* 2002;52(1):1-23.

47.   Walker B. Cortisol--cause and cure for metabolic syndrome? *Diabet Med* 2006;23(12):1281-8.

48.   Dallman M. Stress update Adaptation of the hypothalamic-pituitary-adrenal axis to chronic stress. *Trends Endocrinol Metab* 1993;4(2):62-9.

49.   McEwen B. Protective and damaging effects of stress mediators. *N Engl J Med* 1998;338(3):171-9.

50.   Allison D, Fontaine K, Manson J, et al. Annual deaths attributable to obesity in the United States. *JAMA* 1999;282(16):1530-8.

51.   Haslam D, James W. Obesity. *Lancet* 2005;366(9492):1197-209.

52.   Lau D, Douketis J, Morrison K, et al. 2006 Canadian clinical practice guidelines on the management and prevention of obesity in adults and children [summary]. *CMAJ* 2007;176(8):S1-13.

53.   US Department of Health and Human Services. Healthy People 2010. Washington, DC: US Public Health Service, 2000.

54.   Caballero B. The global epidemic of obesity: an overview. *Epidemiol Rev* 2007;29:1-5.

55.   Flegal K, Carroll M, Ogden C, et al. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 2002;288(14):1723-7.

56.   Ogden C, Carroll M, Curtin L, et al. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 2006;295(13):1549-55.

57.   Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

58.   Franke W, Anderson D. Relationship between physical activity and risk factors for cardiovascular disease among law enforcement officers. *J Occup Med* 1994;36(10):1127-32.

59.   Park Y, Zhu S, Palaniappan L, et al. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National

Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med* 2003;163(4):427-36.

60.   Després J, Moorjani S, Lupien P, et al. Genetic aspects of susceptibility to obesity and related dyslipidemias. *Mol Cell Biochem* 1992;113(2):151-69.

61.   Grundy S. Obesity, metabolic syndrome, and cardiovascular disease. *J Clin Endocrinol Metab* 2004;89(6):2595-600.

62.   RANDLE P, GARLAND P, HALES C, et al. The glucose fatty-acid cycle. Its role in insulin sensitivity and the metabolic disturbances of diabetes mellitus. *Lancet* 1963;1(7285):785-9.

63.   Shulman G. Cellular mechanisms of insulin resistance. *J Clin Invest* 2000;106(2):171-6.

64.   Grundy S. Metabolic complications of obesity. *Endocrine* 2000;13(2):155-65.

65.   Engeli S, Sharma A. Role of adipose tissue for cardiovascular-renal regulation in health and disease. *Horm Metab Res* 2000;32(11-12):485-99.

66.   Wildman R, Muntner P, Reynolds K, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). *Arch Intern Med* 2008;168(15):1617-24.

67.   Stefan N, Kantartzis K, Machann J, et al. Identification and characterization of metabolically benign obesity in humans. *Arch Intern Med* 2008;168(15):1609-16.

68.   Kuczmarski R, Flegal K, Campbell S, et al. Increasing prevalence of overweight among US adults. The National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA* 1994;272(3):205-11.

69.   Sörensen L, Smolander J, Louhevaara V, et al. Physical activity, fitness and body composition of Finnish police officers: a 15-year follow-up study. *Occup Med (Lond)* 2000;50(1):3-10.

70.   Mummery W, Schofield G, Steele R, et al. Occupational sitting time and overweight and obesity in Australian workers. *Am J Prev Med* 2005;29(2):91-7.

71.   Boyce R, Boone E, Cioci B, et al. Physical activity, weight gain and occupational health among call centre employees. *Occup Med (Lond)* 2008;58(4):238-44.

72.   Black E, Holst C, Astrup A, et al. Long-term influences of body-weight changes, independent of the attained weight, on risk of impaired glucose tolerance and Type 2 diabetes. *Diabet Med* 2005;22(9):1199-205.

73. Sonne-Holm S, Sørensen T, Jensen G, et al. Independent effects of weight change and attained body weight on prevalence of arterial hypertension in obese and non-obese men. *BMJ* 1989;299(6702):767-70.

74. Willett W, Manson J, Stampfer M, et al. Weight, weight change, and coronary heart disease in women. Risk within the 'normal' weight range. *JAMA* 1995;273(6):461-5.

75. Alley D, Chang V. Metabolic syndrome and weight gain in adulthood. *J Gerontol A Biol Sci Med Sci* 2010;65(1):111-7.

76. Fine J, Colditz G, Coakley E, et al. A prospective study of weight change and health-related quality of life in women. *JAMA* 1999;282(22):2136-42.

77. Thompson P, Buchner D, Pina I, et al. 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* 2003;107(24):3109-16.

78. Rennie K, McCarthy N, Yazdgerdi S, et al. Association of the metabolic syndrome with both vigorous and moderate physical activity. *Int J Epidemiol* 2003;32(4):600-6.

79. Ford E, Kohl Hr, Mokdad A, et al. Sedentary behavior, physical activity, and the metabolic syndrome among U.S. adults. *Obes Res* 2005;13(3):608-14.

80. Laaksonen D, Lakka H, Salonen J, et al. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes Care* 2002;25(9):1612-8.

81. Lakka T, Laaksonen D, Lakka H, et al. Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Med Sci Sports Exerc* 2003;35(8):1279-86.

82. Carroll S, Cooke C, Butterly R. Metabolic clustering, physical activity and fitness in nonsmoking, middle-aged men. *Med Sci Sports Exerc* 2000;32(12):2079-86.

83. Torjesen P, Birkeland K, Anderssen S, et al. Lifestyle changes may reverse development of the insulin resistance syndrome. The Oslo Diet and Exercise Study: a randomized trial. *Diabetes Care* 1997;20(1):26-31.

84. Eriksson J, Taimela S, Koivisto V. Exercise and the metabolic syndrome. *Diabetologia* 1997;40(2):125-35.

85. Prentice A, Jebb S. Obesity in Britain: gluttony or sloth? *BMJ* 1995;311(7002):437-9.

86. Stamford B, Weltman A, Moffatt R, et al. Status of police officers with regard to selected cardio-respiratory and body compositional fitness variables. *Med Sci Sports* 1978;10(4):294-7.

87. Yoo HL, Eisenmann JC, Franke WD. Independent and Combined Influence of Physical Activity and Perceived Stress on the Metabolic Syndrome in Male Law Enforcement Officers. *J Occup Environ Med* 2009;51(1):46-53.

88. Rice B, Janssen I, Hudson R, et al. Effects of aerobic or resistance exercise and/or diet on glucose tolerance and plasma insulin levels in obese men. *Diabetes Care* 1999;22(5):684-91.

89. Ross R, Dagnone D, Jones P, et al. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. *Ann Intern Med* 2000;133(2):92-103.

90. Ross R, Janssen I, Dawson J, et al. Exercise-induced reduction in obesity and insulin resistance in women: a randomized controlled trial. *Obes Res* 2004;12(5):789-98.

91. Arroll B, Beaglehole R. Does physical activity lower blood pressure: a critical review of the clinical trials. *J Clin Epidemiol* 1992;45(5):439-47.

92. Tran Z, Weltman A, Glass G, et al. The effects of exercise on blood lipids and lipoproteins: a meta-analysis of studies. *Med Sci Sports Exerc* 1983;15(5):393-402.

93. Haskell W. The influence of exercise on the concentrations of triglyceride and cholesterol in human plasma. *Exerc Sport Sci Rev* 1984;12:205-44.

94. Ekelund U, Brage S, Franks P, et al. Physical activity energy expenditure predicts progression toward the metabolic syndrome independently of aerobic fitness in middle-aged healthy Caucasians: the Medical Research Council Ely Study. *Diabetes Care* 2005;28(5):1195-200.

95. Humbarger C, Crouse S, Womack J, et al. Frequency of metabolic syndrome in police officers compared to NCEP III prevalence values. *Med Sci Sports Exerc* 2004;36(5):S161.

96. Sassen B, Cornelissen V, Kiers H, et al. Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors. *Eur J Cardiovasc Prev Rehabil* 2009;16(6):677-83.

97. Bos M, de Vries J, Wolffenbuttel B, et al. The prevalence of the metabolic syndrome in the Netherlands: increased risk of cardiovascular diseases and diabetes mellitus type 2 in one quarter of persons under 60. *Ned Tijdschr Geneeskd* 2007;151(43):2382-8.

98.   Violanti J, Fekedulegn D, Hartley T, et al. Police trauma and cardiovascular disease: association between PTSD symptoms and metabolic syndrome. *Int J Emerg Ment Health* 2006;8(4):227-37.

CHAPTER 3

ASSOCIATION OF PHYSICAL ACTIVITY AND OBESITY TO THE RISK OF THE METABOLIC SYNDROME PROFILE IN POLICE OFFICERS

A manuscript to be submitted to

Occupational and Environmental Medicine

Abstract

Objective: To examine the independent and joint association of physical activity and body mass index (BMI, defined as weight in kilograms divided by the square of height in meters) with the risk of the metabolic syndrome in a sample of police officers. **Methods**: Self-reported physical activity, height and weight to generate BMI, and the metabolic syndrome risk factors were obtained from 448 police officers. **Results**: Among the total participants, 27.5% had the metabolic syndrome, 48.7% and 31.7% were classified as being overweight or obese, respectively. Compared to a normal BMI, being overweight and obese had the odds ratios of 6.75 (95% CI = 1.55 – 29.40) and 10.93 (95% CI = 2.50 – 47.74), respectively, after adjustments for age, race, gender, and smoking status. These associations were independent of levels of physical activity. Moderate and low levels of physical activity had the multivariable-adjusted odds ratios of 1.90 (95% CI = 1.12 – 3.22) and 2.45 (95% CI = 1.23 – 4.88), respectively, although the associations were no longer significant after further adjusting for BMI. There was no significant interaction between physical activity and BMI on the metabolic syndrome score; however within

BMI categories, the metabolic syndrome score was progressively higher across high, moderate, and low physical activity groups. **Discussion**: Higher levels of BMI and lower levels of physical activity were both associated with an increased risk of the metabolic syndrome in police officers, however the strength of the association between physical activity and the metabolic syndrome was significantly attenuated once BMI was considered. While BMI was more strongly associated with an increased risk for the metabolic syndrome than physical activity, high physical activity showed more favorable metabolic risk score than moderate and low physical activity within BMI categories.

Introduction

Obesity is increasing dramatically worldwide and is a serious global public health problem. It has also been identified as a risk factor for cardiovascular disease, Type 2 diabetes, hypertension, and dyslipidemia (1). The metabolic syndrome is a cluster of cardiometabolic risk factors including central obesity, dyslipidemia, hypertension, and glucose intolerance (2). The pathogenesis of the metabolic syndrome has multiple origins, including obesity, physical inactivity, and genetic factors (3). Overweight and obesity are closely associated with an increased risk for the metabolic syndrome (4). The odds of having metabolic syndrome increase with increasing levels of body mass index (BMI) in men and women (5).

Physical activity positively influences individual components of the metabolic syndrome, such as decreasing body weight and visceral fat accumulation, reducing blood pressure, increasing high-density lipoprotein (HDL) cholesterol and decreasing triglyceride levels, and improving insulin sensitivity (6-8). Physical activity also reduces

the risk of the metabolic syndrome *per se* (6, 9). For example, 20 weeks of supervised

aerobic exercise training reduced the prevalence of the metabolic syndrome by 31%

among adults with the metabolic syndrome at baseline (6).

Physical activity involvement and physical demands during active duty police

work are usually limited and insufficient to maintain physical fitness (10). The 24 hour

energy expenditure of police officers does not differ significantly between on-duty and

off-duty days (unpublished observations). In addition, several previous studies showed

that obesity is more prevalent in police officers than in the general public (11, 12). These

conditions may place police officers in a high risk category for the metabolic syndrome.

However, the risk of the metabolic syndrome in the law enforcement profession has been

debated. Humbarger and colleagues (13) found that the prevalence of the metabolic

syndrome among U.S. male police officers was 27.4%, higher than the predicted

prevalence for the U.S. adult males (24.6%) (4). On the other hand, other studies suggest

police officers have a similar or even a lower prevalence of the metabolic syndrome when

compared with the general public (14, 15).

Previous research has shown that physical inactivity is negatively associated with

the metabolic syndrome in LEOs (15). None of the previous studies, however, examined

the combined association of physical activity and body mass index (BMI) on the risk for

the metabolic syndrome in this unique occupational group. Therefore, the purpose of this

study was to examine the independent and joint association of BMI and physical activity

with risk of the metabolic syndrome in a sample of police officers.

Methods

Participants

Sworn law enforcement officers (LEOs) of the Iowa Department of Public Safety (n = 513) were invited to participate in this study; 492 (96%) agreed. Data collection was performed in conjunction with the officers' annual medical evaluation. Participants gave written informed consent. A self-administered questionnaire was distributed to the participants to be completed while they were waiting for the medical evaluation. The questionnaire included questions on socio-demographic status, medical history, physical activity, and smoking history. All procedures were approved by the Institutional Review Board of Iowa State University.

Measurements

Physical Activity: Physical activity was assessed using exercise-related questions that categorize participants' typical physical activity into one of eight levels based on the amount of time spent in programmed recreational, sport, or vigorous physical labor; modest physical activity such as golf, bowling, weight lifting, or yard work; and vigorous physical exercise such as jogging or running, swimming, or cycling (16). For example, level 0 represented no leisure time physical activity whereas level 7 represented involvement in heavy physical activity over 3 hours per week. This questionnaire is highly correlated with directly measured VO_{2peak} ($r = 0.78 – 0.81$) (17).

Metabolic Risk Factors: Systolic (SBP) and diastolic blood pressure (DBP) were measured in a seated position using a standard mercury sphygmomanometer and auscultatory methods after 5 minutes of rest. Blood pressure was determined as the average of two readings. A 12-hour fasting blood sample was obtained by venipuncture.

Serum triglycerides, HDL cholesterol, and plasma glucose were assayed with automated techniques at a laboratory which participates in and meets the quality control standards of the U.S. CDC Lipid Standardization Program (Quest Diagnostics, Wood Dale, IL). Height was measured with no shoes with a stadiometer (Seca, Hanover, MD) to the nearest 0.5 cm. Body mass was measured with light clothing and no shoes on a digital scale (Befour, Inc, Saukville, WI) to the nearest 0.1 kg. BMI was calculated as weight in kilograms divided by height in meters squared.

The Metabolic Syndrome: The metabolic syndrome was defined according to the American Heart Association and National Heart, Lung, and Blood Institute criteria (18). However, instead of waist circumference, abdominal obesity was assessed according to the World Health Organization definition by using a BMI $\geq$30 kg/m^2 (19). Therefore, the metabolic syndrome in this study was defined by the presence of three or more of the following risk factors: (1) BMI $\geq$30 kg/m^2; (2) blood pressure $\geq$130 mmHg systolic or $\geq$85 mmHg diastolic or both or currently using antihypertensive medications; (3) serum triglycerides $\geq$150 mg/dL ($\geq$1.70 mmol/L); (4) HDL cholesterol <40 mg/dL (<1.03 mmol/L) for men and <50 mg/dL (<1.29 mmol/L) for women; and (5) fasting plasma glucose $\geq$100 mg/dL ($\geq$5.6 mmol/L) or currently using antidiabetic medications.

BMI is one of the components of the metabolic syndrome. Consequently, in order to assess the independent association of BMI on the metabolic syndrome, a modified metabolic syndrome was created that excluded BMI from the definition of the metabolic syndrome. Thus, it was defined as having at least three of the remaining four risk factors.

A continuous, quantitative metabolic syndrome score was developed based on the sum of age-standardized residuals (z-scores) for the metabolic syndrome (20). To

normalize for age-related differences in the risk factors, the individual metabolic

syndrome risk factors including BMI, mean arterial pressure (MAP; DBP +1/3[SBP -

DBP]), triglyceride, HDL cholesterol, and fasting glucose, were regressed onto age. The

standardized HDL cholesterol was multiplied by -1 because HDL cholesterol is inversely

related to the metabolic syndrome. The individual z-scores were then subsequently

summed to make the metabolic syndrome score (zMS). A lower score is indicative of a

better metabolic syndrome risk factor profile.

Statistical Analysis

Of the 492 participating LEOs, 44 were excluded from data analysis due to

missing data, yielding complete data on 448 LEOs.

LEOs were categorized into three BMI groups: (1) the normal weight group,

defined as a BMI of <25 kg/m^2, (2) the overweight group, defined as a BMI of ≥ 25 and

<30 kg/m^2, and (3) the obese group, defined as a BMI of ≥ 30 kg/m^2 (21). LEOs were

also categorized into three physical activity groups: (1) low, defined as participants who

reported not participating regularly in programmed recreation, sport or heavy physical

labor, (2) moderate, defined as participants who reported participating regularly in

moderate physical activity for less than 150 minutes or in vigorous physical activity for

less than 60 minutes per week, and (3) high, defined as participants who reported

participating regularly in vigorous physical activity for ≥ 60 minutes or in moderate

physical activity for ≥ 150 minutes per week. This latter score was defined according to

the public health recommendation of the American College of Sports Medicine and the

American Heart Association (22). The BMI and physical activity groups were treated as

categorical variables.

Standard *t* tests and χ^2 tests were used to compare the mean levels of continuous variables and the prevalence of categorical variables between subjects with and without the metabolic syndrome.

Logistic regression analysis was performed to determine odds ratios (ORs) of having the metabolic syndrome in each BMI group and each physical activity group. The normal weight group and the high physical activity group were used as the reference categories in analysis. Covariates included age, race (Caucasian and Others), gender, and smoking history (current, former, and never smokers). A two-way between-groups analysis of variance (BMI group x physical activity group) was used to determine the combined effect of different levels of BMI and physical activity on the metabolic syndrome. Tukey's HSD post hoc comparison test was used.

Statistical significance was defined as *P* <0.05. All statistical analyses were performed using the JMP (Version 8, SAS Institute Inc., Cary, NC) and Statistical Package for Social Science (SPSS forWindows, version 17.0, SPSS Inc, Chicago, IL) programs.

Results

Descriptive characteristics of the total study participants are shown in Table 1. Of the 448 LEOs, 97% were Caucasian and 94% were male. Among the total participants, 27.5% had the metabolic syndrome. Almost half and one third of the participants were classified as being overweight (48.7%) or obese (31.7%), respectively. LEOs with the metabolic syndrome had a higher prevalence of overweight and obesity than those

without the metabolic syndrome (98.4% vs. 73.5%, respectively, *P* <0.0001 for trend).

The prevalence of high physical activity was 34.8% among the total participants. LEOs

without the metabolic syndrome had a higher prevalence of high physical activity than

those with the metabolic syndrome (38.8% and 24.4%, respectively, *P* = 0.0009 for

trend). LEOs with the metabolic syndrome had, as expected, worse values for the

individual metabolic syndrome components (elevated BMI, BP, triglycerides, and

glucose, and lower HDL cholesterol) and zMS (*P* <0.0001 for all) as compared to those

without the metabolic syndrome. There were no significant differences in total

cholesterol, LDL cholesterol, and current smoking status between LEOs with and without

the metabolic syndrome.

Table 2 presents crude and adjusted odd ratios of the metabolic syndrome for

different levels of physical activity. Moderate and low physical activity were

significantly associated with an increased risk for the metabolic syndrome as compared

with high physical activity (OR = 1.67, 95% Confidence interval [CI] = 1.03 – 2.74 and

OR = 3.27, 95% CI = 1.73 – 6.16, respectively) in the unadjusted model. After

controlling for age, race, gender, and smoking status, the associations between the level

of physical activity and the risk of the metabolic syndrome remained significant and the

odds ratios did not change markedly. However, the associations were no longer

significant after further adjusting for BMI.

Being overweight and obese were significantly associated with an increased risk

for the modified metabolic syndrome (Table 3). After adjustments for age, race, gender,

and smoking status, overweight and obesity were associated with ORs of 6.75 (95% CI =

1.55 – 29.40) and 10.93 (95% CI = 2.50 – 47.74), respectively when compared to being

normal weight. Further adjustment for level of physical activity did not alter this association.

Figure 1 presents the combined association of different levels of physical activity and BMI with zMS. There was no significant interaction between physical activity and BMI on zMS; however, there was a linear association between level of physical activity and zMS across BMI categories. Within BMI categories, zMS was progressively higher across high, moderate, and low physical activity groups.

Discussion

The purpose of the current study was to examine the independent and combined association of BMI and physical activity with the metabolic syndrome in a sample of police officers. The results of our analysis demonstrated that higher levels of BMI and lower levels of physical activity were both associated with an increased risk for the metabolic syndrome irrespective of the potential confounders of age, race, gender, and smoking status. The strength of the association between BMI and the modified metabolic syndrome persisted even after further adjustment for physical activity. However, controlling for BMI significantly attenuated the strength of the association between physical activity and the metabolic syndrome, suggesting that BMI has a much greater effect on the metabolic syndrome than does physical activity.

This strong association of BMI with the modified metabolic syndrome compared with physical activity is consistent with previous studies (23, 24). However, within BMI categories, higher levels of physical activity were linearly associated with better

metabolic syndrome risk. For example, LEOs who were in both the normal BMI group and in the high physical activity group had the most favorable metabolic syndrome score, and LEOs who were both obese and had low physical activity had the least favorable metabolic syndrome score (Figure 1).

The findings from the Third National Health and Nutrition Examination Survey showed that the odds of having the metabolic syndrome increase with increasing levels of BMI (5). This study reported that the metabolic syndrome was found in 4.6%, 22.4%, and 59.6% of normal weight, overweight, and obese men, respectively, and in 6.2%, 28.1%, and 50.0% of normal weight, overweight, and obese women, respectively. The results of the current study also showed similar findings; the metabolic syndrome was found in 2.3%, 16.5%, and 59.9% of normal weight, overweight, and obese LEOs, respectively. Thus, most individuals with the metabolic syndrome are either overweight or obese, which suggest that obesity in conjunction with genetic aspects of susceptibility may link the components of the metabolic syndrome (25). Several longitudinal studies also reported obesity as an important risk factor for the metabolic syndrome (23, 26-28). For example, The Coronary Artery Risk Development in Young Adults study showed that relative risk of the metabolic syndrome is significantly increased among participants with higher BMI (relative risk [RR] = 1.89, 95% CI = 1.79 – 2.00 per 4.7 kg/m^2) after controlling for age, race, and gender (23). This study further reported that BMI is a significant predictor of the modified metabolic syndrome (i.e., excluding the abdominal adiposity component in the definition). These findings from previous studies and the current study indicate that high BMI is strongly associated with an increased risk for the metabolic syndrome.

In the presence of obesity and excess visceral fat, multiple products such as non-esterified fatty acids (NEFA) released from adipocytes are produced in abnormal amounts (29). Increased amounts of NEFA into muscle, observed among obese individuals, contribute to insulin resistance (30, 31). An excessive influx of NEFA into the liver leads to increase the triglyceride content of the liver (32). Increased fat in the liver produces insulin resistance as well as atherogenic dyslipidemia, resulting in high serum triglycerides and reduced HDL cholesterol concentrations (29). High NEFA levels may contribute to higher blood pressure also (33). Therefore, obesity is likely to be an underlying risk factor for the metabolic syndrome by raising the risk through individual components including hypercholesterolemia, hypertension, hyperglycemia, and insulin resistance. This is reinforced by our data because zMS, which consisted of these individual components, increased by increasing levels of obesity (Figure 1).

While the metabolic syndrome has increased in the past few decades, the amount of physical activity energy expenditure has declined during this time (34). Our results are consistent with previous findings that lower levels of physical activity or physical inactivity are associated with a greater risk for the metabolic syndrome. Several previous studies have demonstrated that physical activity is associated with a reduced risk of the metabolic syndrome (9, 35-38), and physical inactivity may be an important modifiable risk factor in the etiology of the metabolic syndrome (39, 40). For example, Rennie and colleagues (35) showed that increasing moderate (MET $\geq$3 to 5, including activities such as walking and gardening) and vigorous (MET $\geq$5, including activities such as cycling and swimming) leisure-time physical activity are each associated with reduced odds of the metabolic syndrome after controlling for age, sex, smoking, alcohol intake,

socioeconomic status, and other activity (OR = 0.78, 95% CI = 0.63 – 0.96 and OR =

0.52, 95% CI = 0.40 – 0.67, respectively) in middle-aged populations. Ford and

colleagues found that individuals who did not engage in any moderate or vigorous

leisure-time physical activity are almost twice as likely to have the metabolic syndrome

(OR = 1.90, 95% CI = 1.22 – 2.97) than those who engage in ≥150 minutes per week of

such activity. This association became non-significant after adjustment for age, sex, race

or ethnicity, educational status, smoking status, and alcohol use (OR = 1.46, 95% CI =

0.87 – 2.45) (36). Sedentary behavior is also associated with an increased risk for the

metabolic syndrome. Compared with individuals who engaged in sedentary behaviors

such as viewing television, videos, or working on a computer <1 hour per day outside of

work, those who engaged in sedentary behaviors ≥4 hours per day have an increased risk

for having the metabolic syndrome after controlling for age, sex, race or ethnicity,

educational status, smoking status, and alcohol use (OR = 2.10, 95% CI = 1.27 – 3.47)

(36). In intervention studies, physical activity is, in variable degrees, an effective means

of reducing weight and visceral fat accumulation (7, 41, 42), lowering blood pressure

(43), increasing HDL cholesterol and decreasing triglycerides (44, 45), and improving

insulin sensitivity (41, 42). The results of the current study demonstrated that physical

activity lost the strength of the association with the metabolic syndrome once BMI was

considered, indicating that BMI has a greater influence on the risk for the metabolic

syndrome than does physical activity.

LEOs may be exposed at greater risk for the metabolic syndrome. LEOs have

greater prevalence of increased BMI (over 25 kg/m^2) compared to similarly-aged general

population with similar incomes (82.6% vs. 70.9%, *P* <0.0001) (11). The prevalence of

abdominal obesity and increased BMI are higher among LEOs than the general

population (65.1% vs. 32.7%, P <0.001 and 62.9% vs. 35.4%, P <0.001, respectively)

(46). On the other side, Tharkar and colleagues (46) observed the lack of physical

activity and an abundance of sedentary life style among police officers when compared to

the general population. LEOs either sit or stand for long hours and walk less compared to

the general public (46). In addition, physical activity involvement and physical demands

during active duty police work are usually limited and insufficient to maintain physical

fitness (10).

In spite of these findings, however, the risk of the metabolic syndrome among

U.S. LEOs has been debated. Humbarger and colleagues (13) found that the prevalence

of the metabolic syndrome among 84 U.S. male police officers was 27.4%, slightly

higher than the predicted prevalence for the U.S. adult males (24.6%) (4). On the other

hand, some studies suggest LEOs have a similar or even a lower prevalence of the

metabolic syndrome when compared with the general public. Violanti et al. (14) found

that approximately 16% of 101 LEOs (61 males and 40 females) had the metabolic

syndrome. This prevalence is somewhat lower than that of the U.S. adults (24.1% (4)).

Yoo et al. (15) observed that the metabolic syndrome was present in 23.1% of 386

Caucasian male LEOs, slightly lower than that of the U.S. general white male population

(24.8%) (47). The current study found that 27.5% of LEOs met the criteria for the

metabolic syndrome, which is lower than recent U.S. prevalence data showing that 34%

of U.S. adults had the metabolic syndrome (48). From the previous studies on U.S.

police officers and the current study, the prevalence of the metabolic syndrome in U.S.

LEOs does not seem to be higher than that of the general population. However, the

current study showed that overweight and obese LEOs have a significantly higher prevalence of the metabolic syndrome than normal weight LEOs.

Limitations of the present study warrant discussion. First, the study was cross-sectional in design, and hence, a causal relationship cannot be inferred. Second, our study included LEOs who were mostly Caucasian males, apparently healthy, and recruited from the state of Iowa. Thus, results of this study may not be representative of other LEO populations since few females and other races were included in this study. Third, physical activity was measured by self-report. Errors in self-report may confound the analyses between physical activity and the metabolic syndrome. Fourth, this study used BMI $\geq$30 kg/m^2 instead of waist circumference to define abdominal component of the metabolic syndrome definition; waist circumference was not directly measured in this study. Although BMI is conveniently and widely used to determine obesity in a population study, this measurement does not assess body composition *per se*. Muscle mass, abdominal fat mass, and body fat distribution can vary largely within a narrow range of BMI (49). Nevertheless, a BMI of 28.9 kg/m^2 is approximately equivalent to a waist circumference of 102 cm (50). Thus, a BMI $\geq$30 kg/m^2 was a relatively conservative estimate of obesity. Fifth, odds ratios for the modified metabolic syndrome with different BMI groups showed a wide range of confidence intervals since we were not able to adjust for other lifestyle factors such as eating behaviors that may largely influence this relationship. Eating quality and quantity may influence the metabolic syndrome risk factors such as triglycerides and HDL cholesterol.

In conclusion, lower levels of physical activity and higher BMI were both strongly associated with an increased risk for the metabolic syndrome in police officers.

High BMI was positively associated with the metabolic syndrome independent of physical activity. While BMI was more greatly associated with an increased risk for the metabolic syndrome than physical activity, high physical activity showed more favorable metabolic risk scores than moderate and low physical activity within BMI categories. The metabolic syndrome prevalence in this LEO cohort does not appear to be increased above that of the general population although BMI contributes markedly to the prevalence of the metabolic syndrome in this group. From a clinical perspective, a weight gain of 16.2 kg is sufficient to move a police officer with a height of 180 cm, from normal BMI to overweight BMI group, increasing the risk of the metabolic syndrome approximately eight times (Table 3). These findings indicate that lifestyle modifications emphasizing weight loss and regular physical activity should be encouraged for LEOs, especially overweight, obese, and inactive LEOs, to maintain an optimal BMI and to reduce metabolic syndrome-related morbidity and mortality.

References

1.   Burton B, Foster W. Health implications of obesity: an NIH Consensus Development Conference. *J Am Diet Assoc* 1985;85(9):1117-21.

2.   Grundy SM, Brewer HB, Jr., Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109(3):433-8.

3.   Liese A, Mayer-Davis E, Haffner S. Development of the multiple metabolic syndrome: an epidemiologic perspective. *Epidemiol Rev* 1998;20(2):157-72.

4.   Ford E, Giles W, Mokdad A. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care* 2004;27(10):2444-9.

5.	Park Y, Zhu S, Palaniappan L, et al. The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988-1994. *Arch Intern Med* 2003;163(4):427-36.

6.	Katzmarzyk P, Leon A, Wilmore J, et al. Targeting the metabolic syndrome with exercise: evidence from the HERITAGE Family Study. *Med Sci Sports Exerc* 2003;35(10):1703-9.

7.	Rice B, Janssen I, Hudson R, et al. Effects of aerobic or resistance exercise and/or diet on glucose tolerance and plasma insulin levels in obese men. *Diabetes Care* 1999;22(5):684-91.

8.	Pate R, Pratt M, Blair S, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 1995;273(5):402-7.

9.	Laaksonen D, Lakka H, Salonen J, et al. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes Care* 2002;25(9):1612-8.

10.	Stamford B, Weltman A, Moffatt R, et al. Status of police officers with regard to selected cardio-respiratory and body compositional fitness variables. *Med Sci Sports* 1978;10(4):294-7.

11.	Franke WD, Ramey SL, Shelley MC. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *J Occup Environ Med* 2002;44(12):1182-9.

12.	Franke WD, Collins SA, Hinz PN. Cardiovascular disease morbidity in an Iowa law enforcement cohort, compared with the general Iowa population. *J Occup Environ Med* 1998;40(5):441-4.

13.	Humbarger C, Crouse S, Womack J, et al. Frequency of metabolic syndrome in police officers compared to NCEP III prevalence values. *Med Sci Sports Exerc* 2004;36(5):S161.

14.	Violanti J, Fekedulegn D, Hartley T, et al. Police trauma and cardiovascular disease: association between PTSD symptoms and metabolic syndrome. *Int J Emerg Ment Health* 2006;8(4):227-37.

15.	Yoo HL, Eisenmann JC, Franke WD. 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* 2009;51(1):46-53.

16. Ross RM, Jackson, A.S. *Evaluating aerobic fitness*. Ann Arbor, MI: Benchmark Press; 1990.

17. Jackson A, Blair S, Mahar M, et al. Prediction of functional aerobic capacity without exercise testing. *Med Sci Sports Exerc* 1990;22(6):863-70.

18. Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005;112(17):2735-52.

19. Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications. Report of a WHO Consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus. Geneva: World Health Organization, 1999(WHO/NCD/NCS99.2).

20. Wijndaele K, Beunen G, Duvigneaud N, et al. A continuous metabolic syndrome risk score: utility for epidemiological analyses. *Diabetes Care* 2006;29(10):2329.

21. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res* 1998;6 Suppl 2:51S-209S.

22. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;39(8):1423-34.

23. Carnethon M, Loria C, Hill J, et al. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985-2001. *Diabetes Care* 2004;27(11):2707-15.

24. Mora S, Lee I, Buring J, et al. Association of physical activity and body mass index with novel and traditional cardiovascular biomarkers in women. *JAMA* 2006;295(12):1412-9.

25. Després J, Moorjani S, Lupien P, et al. Genetic aspects of susceptibility to obesity and related dyslipidemias. *Mol Cell Biochem* 1992;113(2):151-69.

26. Palaniappan L, Carnethon M, Wang Y, et al. Predictors of the incident metabolic syndrome in adults: the Insulin Resistance Atherosclerosis Study. *Diabetes Care* 2004;27(3):788-93.

27. Srinivasan S, Myers L, Berenson G. Predictability of childhood adiposity and insulin for developing insulin resistance syndrome (syndrome X) in young adulthood: the Bogalusa Heart Study. *Diabetes* 2002;51(1):204-9.

28. Wilson P, Kannel W, Silbershatz H, et al. Clustering of metabolic factors and coronary heart disease. *Arch Intern Med* 1999;159(10):1104-9.

29. Grundy S. Obesity, metabolic syndrome, and cardiovascular disease. *J Clin Endocrinol Metab* 2004;89(6):2595-600.

30. RANDLE P, GARLAND P, HALES C, et al. The glucose fatty-acid cycle. Its role in insulin sensitivity and the metabolic disturbances of diabetes mellitus. *Lancet* 1963;1(7285):785-9.

31. Shulman G. Cellular mechanisms of insulin resistance. *J Clin Invest* 2000;106(2):171-6.

32. Grundy S. Metabolic complications of obesity. *Endocrine* 2000;13(2):155-65.

33. Engeli S, Sharma A. Role of adipose tissue for cardiovascular-renal regulation in health and disease. *Horm Metab Res* 2000;32(11-12):485-99.

34. Prentice A, Jebb S. Obesity in Britain: gluttony or sloth? *BMJ* 1995;311(7002):437-9.

35. Rennie K, McCarthy N, Yazdgerdi S, et al. Association of the metabolic syndrome with both vigorous and moderate physical activity. *Int J Epidemiol* 2003;32(4):600-6.

36. Ford E, Kohl Hr, Mokdad A, et al. Sedentary behavior, physical activity, and the metabolic syndrome among U.S. adults. *Obes Res* 2005;13(3):608-14.

37. Lakka T, Laaksonen D, Lakka H, et al. Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. *Med Sci Sports Exerc* 2003;35(8):1279-86.

38. Carroll S, Cooke C, Butterly R. Metabolic clustering, physical activity and fitness in nonsmoking, middle-aged men. *Med Sci Sports Exerc* 2000;32(12):2079-86.

39. Torjesen P, Birkeland K, Anderssen S, et al. Lifestyle changes may reverse development of the insulin resistance syndrome. The Oslo Diet and Exercise Study: a randomized trial. *Diabetes Care* 1997;20(1):26-31.

40. Eriksson J, Taimela S, Koivisto V. Exercise and the metabolic syndrome. *Diabetologia* 1997;40(2):125-35.

41. Ross R, Dagnone D, Jones P, et al. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. A randomized, controlled trial. *Ann Intern Med* 2000;133(2):92-103.

42. Ross R, Janssen I, Dawson J, et al. Exercise-induced reduction in obesity and insulin resistance in women: a randomized controlled trial. *Obes Res* 2004;12(5):789-98.

43. Arroll B, Beaglehole R. Does physical activity lower blood pressure: a critical review of the clinical trials. *J Clin Epidemiol* 1992;45(5):439-47.

44. Tran Z, Weltman A, Glass G, et al. The effects of exercise on blood lipids and lipoproteins: a meta-analysis of studies. *Med Sci Sports Exerc* 1983;15(5):393-402.

45. Haskell W. The influence of exercise on the concentrations of triglyceride and cholesterol in human plasma. *Exerc Sport Sci Rev* 1984;12:205-44.

46. Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

47. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. *JAMA* 2002;287(3):356-9.

48. Ervin R. 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. *Natl Health Stat Report* 2009(13):1-7.

49. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation presented at: the World Health Organization. Geneva, Switzerland, June 3-5, 1997.

50. Wannamethee S, Shaper A, Lennon L, et al. Metabolic syndrome vs Framingham Risk Score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Arch Intern Med* 2005;165(22):2644-50.

Table 1. Descriptive characteristics of study participants with and without the metabolic syndrome

Variable	Total (n = 448)	Metabolic Syndrome Absent (n=325)	Present (n=123)	t or χ^2	P-value
Age	37.6 ± 9.4 (19 – 59)	35.7 ± 8.7 (19 – 58)	42.7 ± 9.1 (23 – 59)	7.51	<0.0001
BMI (kg/m^2)	28.5 ± 4.0 (19.27 – 43.77)	27.3 ± 3.5 (19.27 – 43.61)	31.6 ± 3.6 (24.42 – 43.77)	11.53	<0.0001
SBP (mmHg)	126.5 ± 10.4 (102 – 168)	124.5 ± 9.2 (102 – 153)	131.9 ± 11.3 (107 – 168)	7.20	<0.0001
DBP (mmHg)	85.4 ± 8.0 (59 – 112)	84.0 ± 7.8 (59 – 110)	89.3 ± 6.9 (74 – 112)	6.58	<0.0001
MAP (mmHg)	99.1 ± 7.9 (75.3 – 123.0)	97.5 ± 7.5 (75.3 – 121.7)	103.5 ± 7.0 (87.3 – 123.0)	7.69	<0.0001
Triglycerides	129.1 ± 71.7 (35 – 400)	109.3 ± 58.4 (35 – 391)	181.6 ± 77.2 (49 – 400)	10.66	<0.0001
HDL	47.9 ± 11.5 (25 – 110)	50.8 ± 11.2 (27 – 110)	40.4 ± 8.4 (25 – 71)	-9.32	<0.0001
Glucose	92.3 ± 10.7 (48 – 193)	89.8 ± 7.1 (48 – 119)	98.9 ± 14.9 (74 – 193)	8.65	<0.0001
Total cholesterol	192.6 ± 36.8 (114 – 344)	191.7 ± 35.5 (115 – 294)	194.9 ± 40.0 (114 – 344)	0.81	0.4160
LDL	118.9 ± 31.5 (38 – 250)	119.0 ± 30.6 (38 – 205)	118.5 ± 33.8 (46 – 250)	-0.17	0.8622
Z-MS	-0.1 ± 3.0 (-9.6 – 11.7)	-1.2 ± 2.5 (-9.6 – 6.2)	2.7 ± 2.4 (-3.6 – 11.7)	14.60	<0.0001
Z-MMS	-0.09 ± 2.43 (-7.4 – 11.8)	-0.90 ± 2.00 (-7.4 – 6.2)	2.02 ± 2.16 (-2.8 – 11.8)	13.48	<0.0001
Race (%)				0.13	0.7196
White	435 (97.1)	315 (96.9)	120 (97.6)		
Others	13 (2.9)	10 (3.1)	3 (2.4)		
Gender (%)				5.03	0.0249
Males	423 (94.4)	302 (92.9)	121 (98.4)		
Females	25 (5.6)	23 (7.1)	2 (1.6)		
Tobacco use (%)				5.40	0.0673

Table 1. (Continued)

| Variable | Total (n = 448) | Metabolic Syndrome | | t or χ^2 | P-value |
		Absent (n=325)	Present (n=123)		
Current	70 (15.6)	51 (15.7)	19 (15.5)		
Former	156 (34.8)	123 (37.9)	33 (26.8)		
Never	222 (49.6)	151 (46.4)	71 (57.7)		
Physical Activity (%)				13.96	0.0009
Low	64 (14.3)	36 (11.1)	28 (22.8)		
Moderate	228 (50.9)	163 (50.1)	65 (52.8)		
High	156 (34.8)	126 (38.8)	30 (24.4)		
BMI groups (%)				115.98	<0.0001
Normal	88 (19.6)	86 (26.5)	2 (1.6)		
Overweight	218 (48.7)	182 (56.0)	36 (29.3)		
Obese	142 (31.7)	57 (17.5)	85 (69.1)		

Values are mean ± standard deviation (range) or number (%).
Abbreviations: LEO, law enforcement officer; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; Z-MS, the metabolic syndrome Z score

Table 2. Crude and adjusted odds ratios for the metabolic syndrome with different levels of physical activity

PA category	Univariate model	Multivariate models		
		A*	B†	C‡
High	1.0	1.0	1.0	1.0
Moderate	1.67 (1.03 – 2.74)	1.75 (1.04 – 2.93)	1.90 (1.12 – 3.22)	1.45 (0.80 – 2.66)
Low	3.27 (1.73 – 6.16)	2.25 (1.15 – 4.40)	2.45 (1.23 – 4.88)	2.08 (0.95 – 4.56)

* adjusted for age
† adjusted for age, race, gender and smoking history
‡ adjusted for age, race, gender, smoking history, and body mass index group
Abbreviation: PA, physical activity

Table 3. Crude and adjusted odds ratios for the modified metabolic syndrome with different body mass index groups

BMI category	Univariate model	Multivariate model*		
		A*	B†	C‡
Normal	1.0	1.0	1.0	1.0
Overweight	8.50 (2.00 – 36.14)	7.83 (1.82 – 33.72)	6.75 (1.55 – 29.40)	6.52 (1.49 – 28.57)
Obese	16.27 (3.82 – 69.38)	12.58 (2.91 – 54.36)	10.93 (2.50 – 47.74)	10.46 (2.38 – 46.05)

* adjusted for age
† adjusted for age, race, gender and smoking history
‡ adjusted for age, race, gender, smoking history, and physical activity levels
Abbreviation: BMI, body mass index

Figure 1. The metabolic syndrome score according to the physical activity level and body mass index
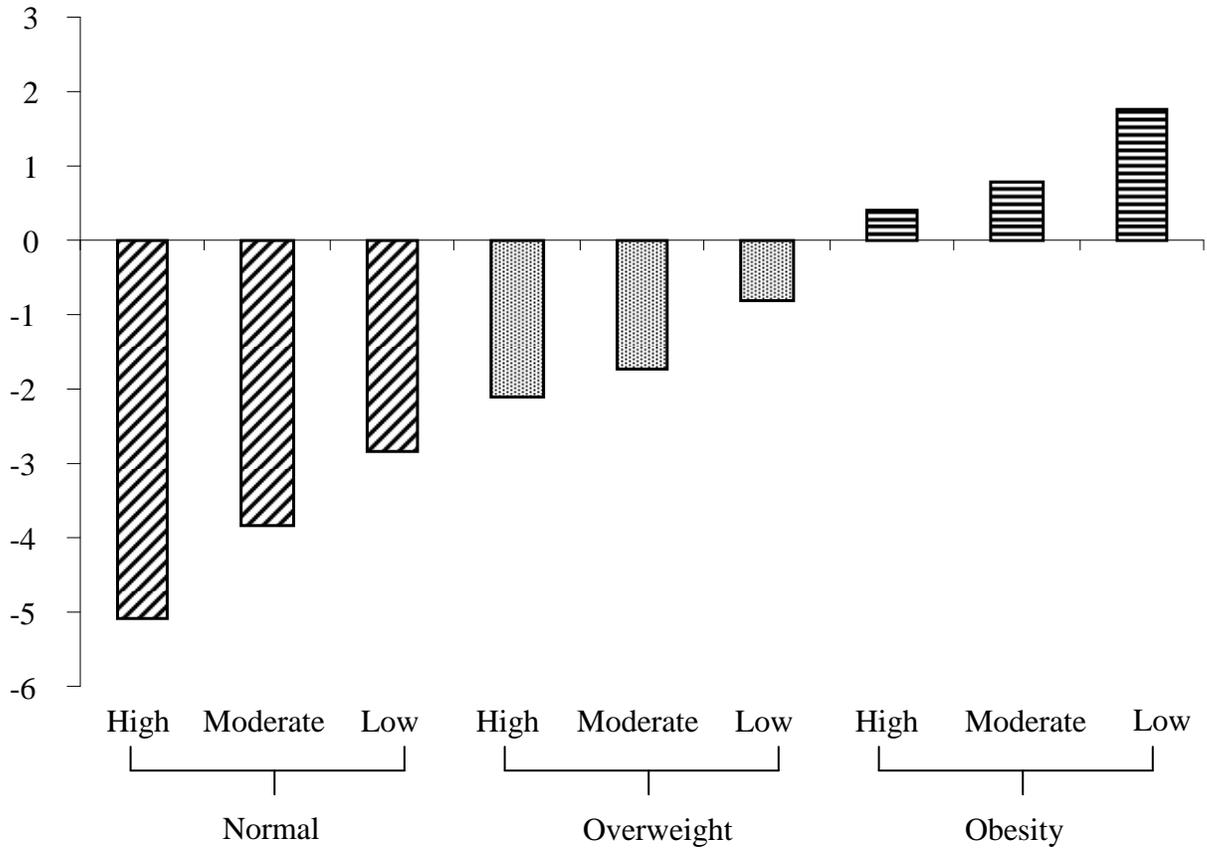
Adjusted for age, race, gender, and smoking status

Acknowledgments

CHAPTER 4

WEIGHT GAIN AND THE METABOLIC SYNDROME IN POLICE OFFICERS

A manuscript to be submitted to

Occupational and Environmental Medicine

Abstract

Objective: To examine 1) the weight history in a sample of police officers relative to

their years of experience as a law enforcement officer (LEO) and 2) the association of

weight gain after joining the law enforcement occupation to the metabolic syndrome and

its subcomponents in LEOs. **Methods**: Current weight and self-reported weight at the

time of graduation from the police academy were measured to assess weight history

among 415 police officers. **Results**: The mean age and years of experience as a LEO

were 38±9 and 14±9 years, respectively. The mean weight gain since the police academy

and weight gain per year while working as a LEO were 13±10 kg and 1.4±1.6 kg/year,

respectively. There were linear trends indicating that as LEOs gain more years of

experience, there is an increase in current BMI and total weight gain since the police

academy. In contrast, there was an inverse linear trend indicating that LEOs with fewer

years of experience, have the most annual weight gain. Compared with the weight gain

group of <0.5 kg/year, the weight gain groups of 1.0 to <1.5 and ≥1.5 kg/year were

significantly associated with an increased risk for the modified metabolic syndrome (i.e.,

excluding BMI) and a high level of fasting glucose. LEOs in the highest weight gain

group (≥1.5 kg/year) had a markedly increased risk for the modified metabolic syndrome relative to those in the lowest weight gain group (<0.5 kg/year) (OR = 5.08, 95% CI = 1.84 – 14.08). These associations were no longer significant after consideration of the current BMI. **Discussion**: Weight gain occurs quicker early in LEO career and slower when LEOs are older. Weight gain is associated with an increased risk of the metabolic syndrome, but this association is not independent of the current BMI among LEOs. Attained BMI is a more significant factor for metabolic health risk than weight gain among LEOs.

Introduction

Obesity is a common health condition (1) accompanied by a high prevalence of cardiovascular disease, Type 2 diabetes, hypertension, and dyslipidemia (2, 3). Overweight and obesity are also associated with an increased risk for the metabolic syndrome (4), a cluster of cardiometabolic risk factors including central obesity, dyslipidemia, hypertension, and glucose intolerance (5). Nevertheless, recent studies have found a normal cardiometabolic risk profile among overweight and obese individuals and a high cardiometabolic risk profile among normal-weight individuals (6, 7). The variability in cardiomatebolic risk observed among individuals of similar body mass index (BMI) has turned researchers' attention from BMI itself to weight history (8, 9). A number of studies that assessed the association between weight history during adulthood and different health outcomes in various populations have found that weight

gain in adulthood is associated with increasing risk of cardiovascular and metabolic

diseases (9-12).

Work environment may greatly influence weight gain and obesity. Sedentary

occupations with high levels of sitting time and lower demand for physical activity have

been associated with weight gain and obesity (13, 14). The police occupation requires

occasional physical demands but mostly involves sedentary tasks (15). Previous studies

showed that obesity may be more prevalent in police officers compared to the general

public. Law enforcement officers (LEOs) have a greater prevalence of increased BMI

(>25 kg/m^2) compared to a similarly-aged general population with similar incomes

(82.6% vs. 70.9%, P <0.0001) (16). Overweight (BMI >27 kg/m^2) is more prevalent in

LEOs compared with the general public of similar age (55.2% vs. 34.8%, P <0.001) (17).

The prevalence of abdominal obesity and increased BMI are higher among LEOs than the

general population (65.1% vs. 32.7%, P <0.001 and 62.9% vs. 35.4%, P <0.001,

respectively) (18). Furthermore, police officers tend to get fatter faster over time than the

general population (19). Therefore, weight history during the career as a LEO may be

related to an increased prevalence of metabolic health risk in this occupation.

Previous studies have assessed the change in body weight in police officers (15,

19). To the best of our knowledge, however, none of the previous studies examined the

association of weight history and the metabolic health risk among this unique population.

Therefore, the purpose of this study was to examine 1) the weight history in a sample of

police officers based on their years of experience as a LEO and 2) the association of

weight gain after joining in law enforcement occupation to the metabolic syndrome and

its subcomponents in police officers.

Methods

Participants

Sworn LEOs of the Iowa Department of Public Safety were invited to participate in this study. Of the 513 LEOs eligible for evaluation, 492 agreed to participate in this study (96% response rate). Data collection was performed in conjunction with the officers' annual medical evaluation. Participants gave written informed consent and completed questionnaires at the time of their annual medical evaluation on socio-demographics, medical history, physical activity history, and smoking history. All procedures were approved by the Institutional Review Board of Iowa State University.

Measures

Weight history: Current weight was measured while participants wore light clothing and no shoes on a digital scale (Befour, Inc, Saukville, WI) to the nearest 0.1 kg. As a part of their annual medical evaluation, participants self-reported their academy year and weight at the time they graduated from the police academy (GradWt). Recalled past weight has been found to be strongly correlated with previously measured weight ($r = 0.74$ for men, and $r = 0.74$ for women) (20). Nevertheless, to assess the validity of self-reported weight with previously measured weight among LEOs, measured GradWt was collected from 50 randomly selected police officers among the subgroup of LEOs who joined the police academy after 1992. Recalled past weight was highly correlated with previously measured weight in these participants ($r = 0.89$, $P < 0.0001$).

Metabolic Risk Factors: Systolic (SBP) and diastolic blood pressure (DBP) were measured in the seated position after a 5 minute rest using a standard mercury sphygmomanometer and the auscultatory method. Blood pressure was determined as the

average of two readings. A 12-hour fasting blood sample was obtained by venipuncture.

Serum triglycerides, high-density lipoprotein (HDL) cholesterol, and plasma glucose

were assayed with automated techniques at a laboratory which participates in and meets

the quality control standards of the U.S. CDC Lipid Standardization Program (Quest

Diagnostics, Wood Dale, IL). Height was measured with a stadiometer (Seca, Hanover,

Maryland) to the nearest 0.5 cm. BMI was calculated as weight in kilograms divided by

height in meters squared; a BMI $\geq$25.0 kg/m^2 and $\geq$30.0 kg/m^2 were the criteria for

overweight and obesity, respectively.

The Metabolic syndrome: The metabolic syndrome was defined according to the

American Heart Association/National Heart, Lung, and Blood Institute criteria (21).

However, abdominal obesity was assessed according to the World Health Organization

definition by using a BMI $\geq$30 kg/m^2 (22) rather than by waist circumference. Therefore,

the metabolic syndrome in this study was defined by the presence of three or more of the

following risk factors: (1) BMI $\geq$30 kg/m^2; (2) blood pressure $\geq$130 mmHg systolic or

$\geq$85 mmHg diastolic or both or currently using antihypertensive medications; (3) serum

triglycerides $\geq$150 mg/dL ($\geq$1.70 mmol/L); (4) HDL cholesterol <40 mg/dL (<1.03

mmol/L) for men and <50 mg/dL (<1.29 mmol/L) for women; and (5) fasting plasma

glucose $\geq$100 mg/dL ($\geq$5.6 mmol/L) or currently using antidiabetic medications.

Because BMI is correlated with body weight and is one of the components of the

metabolic syndrome, a modified definition of metabolic syndrome was used. BMI was

excluded from the definition of the metabolic syndrome, such that the modified metabolic

syndrome was defined by the presence of three or more of the remaining four risk factors.

A continuous, quantitative metabolic syndrome score was developed based on the sum of age-standardized residuals (z-scores) for the metabolic syndrome (23). To normalize for age-related differences in the risk factors, the individual metabolic syndrome risk factors of BMI, mean arterial pressure (MAP; DBP+1/3[SBP-DBP]), triglyceride, HDL cholesterol, and fasting plasma glucose, were regressed onto age. The standardized HDL cholesterol was multiplied by -1 since HDL cholesterol is inversely related to the metabolic syndrome. The individual z-scores were subsequently summed to derive the metabolic syndrome score (zMS). A lower score is indicative of a better metabolic syndrome risk factor profile. In addition, a modified metabolic syndrome score (zMMS; i.e., excluding BMI) was created in a similar fashion.

Statistical Analysis

To assess weight history based on duration as a LEO, LEOs were categorized into five groups: (1) 1 to 5, (2) 6 to 10, (3) 11 to 15, (4) 16 to 20, and (5) more than 20 years of experience as a LEO. A one-way analysis of variance (ANOVA) and χ^2 tests were used to compare the mean levels of continuous variables and the prevalence of categorical variables among these subgroups.

LEOs were also categorized into four weight gain groups: (1) <0.5, (2) 0.5 to <1.0, (3) 1.0 to <1.5, and (4) ≥1.5 kg of weight gain per year (kg/year). This was done to assess the association of weight history after becoming a law enforcement officer with the metabolic syndrome. Weight gain per year was calculated as weight gain since graduating from the police academy divided by years of experience as a LEO. Since we did not assess whether weight loss was intentional or unintentional, participants who lost weight were excluded from the data analysis. This is because unintentional weight loss

may confound associations between weight change and health outcomes (24). A one-way ANOVA and χ^2 tests were used to compare the mean levels of continuous variables and the prevalence of categorical variables among weight gain per year subgroups. Tukey's HSD post hoc comparison test was used to locate significant differences.

Logistic regression analysis was used to determine the odds ratios of having the metabolic syndrome and its subcomponents in each weight gain subgroup. The weight gain <0.5 kg/year group was used as the reference category in all analyses. The first model was adjusted for age. The second model was adjusted for age, sex, race (Caucasians and others), smoking history (current, former, and never smoking), and physical activity history (low, moderate, or vigorous activity in the past 30 days). In the last model, the current BMI was further adjusted to examine whether weight history was associated with metabolic health risk that is independent of current weight status.

Pearson correlation coefficients between GradWt, current weight, BMI when graduating from the police academy (Grad BMI), current BMI, weight gain since the police academy, weight gain per year, years of experience as a LEO, age, zMS, and zMMS were calculated.

Statistical significance was defined as $P < 0.05$. All statistical analyses were performed using the JMP (Version 8. SAS Institute Inc., Cary, NC) and Statistical Package for Social Science (SPSS forWindows, version 17.0, SPSS Inc, Chicago, IL) programs.

Results

Of the 492 LEOs participated, 41 were missing weight history data and 36 were missing covariate data, leaving 415 LEOs for the first set of data analysis. Of these 415, 94.2% were male and 96.9% were Caucasian.

The weight history of the study participants based on years of experience as a LEO is presented in Table 1. LEOs had similar Grad BMI regardless of years of experience as a LEO. The mean weight gain since the police academy and the mean weight gain per year while working as a LEO were 12.7 kg and 1.4 kg/year, respectively. There were linear trends indicating that as LEOs have more years of experience, there is an increase in current BMI and total weight gain since the police academy. Among LEOs with more than 20 years of experience as a LEO, only 13% were in the normal BMI group and almost half of them (47%) were in the obese BMI group. In contrast, there was an inverse linear trend indicating that LEOs with fewest years of experience, gain the most weight per year as a LEO. Among LEOs with one to five years of experience as a LEO, almost one third (31%) were in the normal BMI group and only 9% were in the obese BMI group.

The figure presents a trend of weight history of LEOs based on years of experience as a LEO. LEOs with fewer years of experience tend to have a higher proportion of increased weight gain per year than LEOs with more years of experience, who tend to have a higher proportion of more modest weight gain per year.

Of the 415 participants, LEOs with one to five years of experience as a LEO (n = 88) were excluded from the second set of data analysis since weight gain per year among this group was quite dramatic (2.9 kg/year). Furthermore, LEOs who lost weight since

the police academy (n = 12) were further excluded from the data analysis to assess the association of weight gain and the metabolic health risk. Thus, a total of 315 LEOs were included in the following set of data analyses. Of these 315 LEOs, 94% were male and 97.1% were Caucasian.

The descriptive characteristics of these participants according to the weight gain categories are shown in Table 2. There were inverse linear associations between the weight gain category, age and years of experience as a LEO; as weight gain per year becomes higher, LEOs are younger and have fewer years of experience as a LEO. Current weight, current BMI, weight gain since the police academy, triglycerides, zMS, and zMMS were positively associated with weight gain category, whereas HDL cholesterol was inversely associated. However, there were no significant differences in BMI and GradWt based on weight gain category. Overall, 107 LEOs (34.0%) were classified as having the metabolic syndrome and 68 LEOs (21.6%) as having the modified metabolic syndrome. As weight gain per year becomes greater, the prevalence of the metabolic syndrome and the modified metabolic syndrome are also greater.

Table 3 shows the odds ratio of the metabolic syndrome and its components in relation to weight gain category. After adjustments for age, race, gender, exercise history, and smoking history, the weight gain groups of 1.0 to <1.5 and ≥1.5 kg/year were significantly associated with an increased risk for the metabolic syndrome, the modified metabolic syndrome, and a high level of fasting glucose compared with the weight gain group of <0.5 kg/year. The weight gain group ≥1.5 kg/year was associated with an elevated risk for high blood pressure, high triglycerides, and low HDL cholesterol level compared with weight gain group of <0.5 kg/year after controlling for these covariates.

The highest risk was associated with the highest weight gain group ($\geq$1.5 kg/year); LEOs in this group had more than fourteen times the risk for the metabolic syndrome and five times the risk for the modified metabolic syndrome relative to those in the lowest weight gain group (<0.5 kg/year) (odds ratio [OR] = 14.84, 95% confidence interval [CI] = 5.24 – 42.05 and OR = 5.08, 95% CI = 1.84 – 14.08). However, after further adjustment for current BMI (Table 3, Model c), these associations were no longer significant.

Table 4 illustrates the correlations among weight related variables and the metabolic syndrome scores. The current BMI was highly correlated with GradWt, current weight, Grad BMI, weight gain since the police academy, weight gain per year, years of experience as a LEO, age, zMS, and zMMS (P <0.05 for all).

Discussion

The purpose of the current study was to examine weight history while working as a LEO and the effect of weight gain on metabolic health risk in police officers. The main findings of our study were 1) LEOs gain the most weight early in their career as a LEO and 2) weight gain is associated with the metabolic syndrome and its individual components, although this association is no longer significant after controlling for current BMI.

Previous studies have found that body weight of U.S. adult men and women increases 0.24 kg/year (25), while body weight of Finnish police officers increased 0.48 kg/year during a 15-year follow-up (15). Our results showed that U.S. police officers gain 1.4 kg of body weight per year while working as a LEO, indicating a higher weight gain per year than either the general U.S. population or Finnish police officers. These

differences in weight gain per year may simply be due to differences in general characteristics among populations selected in each study. The present study population only included police officers aged 19 to 59, who are mainly Caucasian male, and considered weight history since their graduation from the police academy. The study of the general U.S. adult population (25) included a wider age range (20 to 74 years), and the Finnish police officer study (15) included only males between 42 to 61 years. Although there are differences in each study design, weight gain per year among U.S. police officers is markedly high in comparison.

In a cross-sectional study, Franke et al. (19) found that police officers tend to be leaner than similarly aged non-officers when they are younger (i.e., ≤48 years), but they get fatter faster over time, such that they are fatter than their peers when they are older (i.e., >48 years). Since we did not have a comparison group, we were not able to compare the trend of weight gain in police officers relative to non-officers. However, our study found that LEOs in the earlier stage of police career tend to gain more weight than in the later stage of police career (Figure 1). Thus, weight gain is faster when LEOs are younger and slower when LEOs are older. Especially, weight gain of LEOs for the first five years of the police career is quite dramatic (2.9 kg/year, Table 1). We speculate that life style changes, health behaviors, or both may explain this trend. When police officers graduate from the police academy, they are physically fit due to the rigors of the academy. However after beginning their job as LEOs, police officers are involved in mostly sedentary tasks (15). In addition, shift work and working overtime as a part of policing job characteristics may lead LEOs to unhealthy life styles such as irregular meal and sleep time. The sudden life style and, possibly, health behavior changes seen after

beginning a policing career may explain part of the marked weight gain. A prospective study of weight and weight change (Galanis et al. (26)) found that weight gain in early adulthood is positively related to a greater risk of coronary heart disease more so than weight gain in later life. Thus, efforts should be taken to understand the reasons underlying the weight gain in relatively young police officers, in order to prevent potential negative consequences.

The second purpose of our study was to examine the influence of weight gain on metabolic health risk in police officers. As mentioned earlier, weight gain among LEOs with one to five years of experience was dramatic; therefore, these participants were excluded from the data analysis to remove any influences from these analyses. Since the resting group of LEOs had a wide range of duration as a LEO (6 to 37 years), weight gain was expressed as weight gain per year instead of absolute weight gain to eliminate any effect due to different years of experience as a LEO.

The results suggest that annual weight gain during a policing career is associated with the metabolic syndrome and its individual components. Compared with LEOs with weight gain of <0.5 kg/year, LEOs with weight gain ≥1.5 kg/year had significantly increased odds of the metabolic syndrome, high blood pressure, high triglycerides, low HDL cholesterol, and high fasting glucose even after controlling for age, race, exercise history, and smoking status. The association between weight gain and the modified metabolic syndrome risk (i.e., excluding BMI) remained significant as weight gain was associated with hypertension, dyslipidemia, and high fasting glucose. Our findings are consistent with previous findings (12, 27-29). Although the classification of weight gain groups differed, the majority of these studies on weight history and cardiovascular risk

found an association between weight gain during adult life and adverse health outcomes after controlling for absolute body weight in early adulthood. For example, risk for the metabolic syndrome increases 23% per 4.5 kg of weight gained over 15 years among men and women aged 18 to 30 years (relative risk [RR] = 1.23, 95% CI = 1.20 – 1.27) (30).

Several recent studies assessed the association of weight gain and caridiometabolic risk while controlling for attained BMI. The results have been inconsistent between studies. Alley and Chang (10) showed that weight gain during the previous 10 to 15 years of the current age is associated with an increased risk of low HDL cholesterol, high triglycerides, and the metabolic syndrome after adjustment for the current BMI among adults aged 50 to 64 years. Black et al. (31) found that weight gain since age 20 is related to increased risk of impaired glucose tolerance independent of attained BMI in middle aged men (OR = 1.10 per unit kg/m^2 of BMI gain, 95% CI = 1.03 – 1.17). In addition, Sonne-Holm (32) showed that a history of weight gain is associated with an increased risk of hypertension, independent of the effect of attained weight. Although these positive associations, independent of attained weight, may explain the presence of metabolically healthy overweight and obese individuals and high risk normal weight individuals, the mechanisms underling these associations are not completely understood.

In contrast to these findings, Bowman et al. (11) showed that an increase of BMI ≥ 2.0 kg/m^2 after eight years is associated with an increased risk of cardiovascular disease events (a multivariable-adjusted RR = 1.39, 95% CI = 1.16 – 1.68) compared to a stable BMI (± 0.5 kg/m^2) among middle aged men, but this association is no longer significant when the current BMI is considered (RR = 1.00, 95% CI = 0.81 – 1.23). Our results also

showed a similar finding of Bowman et al. (11). Although weight gain was associated

with an increased risk of metabolic health risk after controlling for covariates, there was a

dramatic attenuation in the odds ratios after further adjusting for the attained BMI (Table

3). This indicates that the attained BMI had a much greater influence on the metabolic

syndrome and its individual components than did weight gain in this sample of police

officers. These contradictory findings between weight gain studies may be due to

differences in study designs to define weigh gain groups (for example, weight gain based

on change in BMI, change in body weight, or change in weight/year) or different

populations assessed in each study, or both.

The results of the current study showed a high correlation between weight gain

since the police academy and the current weight ($r = 0.70$). The positive association of

weight gain and the metabolic health risk from our study and previous studies may

simply be due to the fact that higher weight gain leads to a higher current weight that is

eventually associated with adverse health status such as high blood pressure, low HDL

cholesterol, high triglycerides, and high fasting insulin (29).

Limitations of the present study warrant discussion. First, the study was cross-

sectional in design, and hence, a causal relationship cannot be inferred. Second, our

study included LEOs who were mostly Caucasian male, apparently healthy, and recruited

from the state of Iowa. Thus, the results of this study may not be representative of the

broader LEO population since only a few females and other races were included in this

study. Third, weight history were measured by self-report. Errors in self-report may

confound the analyses between weight history and the metabolic syndrome. However,

the correlation between self-reported weight when entering the police academy and

previously measure weight among this group of LEO was quite high ($r = 0.89$). Fourth,

this study used BMI ≥ 30 kg/m^2 instead of waist circumference to define the abdominal

component of the metabolic syndrome; waist circumference was not directly measured in

this study. Although BMI is conveniently and widely used to determine obesity in

population studies, this measurement does not assess body composition *per se*. Muscle

mass, abdominal fat mass, and body fat distribution can vary largely within a narrow

range of BMI (1). Nevertheless, a BMI of 28.9 kg/m^2 is approximately equivalent to a

waist circumference of 102 cm (33). Thus, a BMI ≥ 30 kg/m^2 was a relatively

conservative estimate of obesity. Fifth, this study did not explicitly adjust for diet and

other life style confounders. Eating quality and quantity can influence the metabolic risk

factors such as triglycerides and HDL cholesterol.

In conclusion, weight gain occurs quicker when LEOs are younger and slower

when LEOs are older. An increasing weight gain is associated with an increased risk of

the metabolic syndrome and its individual components, but this association is not

independent of the current BMI among LEOs. Attained BMI is a more significant factor

for metabolic health risk than weight gain in adulthood among LEOs. Thus, the

maintenance of an optimal BMI and prevention of further weight gain is an important

health concern among police officers.

References

1.   World Health Organization. Obesity: preventing and managing the global
      epidemic. Report of a WHO Consultation presented at: the World Health
      Organization. Geneva, Switzerland, June 3-5, 1997.

2.   Burton B, Foster W. Health implications of obesity: an NIH Consensus Development Conference. *J Am Diet Assoc* 1985;85(9):1117-21.

3.   Haslam D, James W. Obesity. *Lancet* 2005;366(9492):1197-209.

4.   Ford E, Giles W, Mokdad A. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care* 2004;27(10):2444-9.

5.   Grundy SM, Brewer HB, Jr., Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109(3):433-8.

6.   Wildman R, Muntner P, Reynolds K, et al. The obese without cardiometabolic risk factor clustering and the normal weight with cardiometabolic risk factor clustering: prevalence and correlates of 2 phenotypes among the US population (NHANES 1999-2004). *Arch Intern Med* 2008;168(15):1617-24.

7.   Stefan N, Kantartzis K, Machann J, et al. Identification and characterization of metabolically benign obesity in humans. *Arch Intern Med* 2008;168(15):1609-16.

8.   Colditz G, Willett W, Rotnitzky A, et al. Weight gain as a risk factor for clinical diabetes mellitus in women. *Ann Intern Med* 1995;122(7):481-6.

9.   Willett W, Manson J, Stampfer M, et al. Weight, weight change, and coronary heart disease in women. Risk within the 'normal' weight range. *JAMA* 1995;273(6):461-5.

10.   Alley D, Chang V. Metabolic syndrome and weight gain in adulthood. *J Gerontol A Biol Sci Med Sci* 2010;65(1):111-7.

11.   Bowman T, Kurth T, Sesso H, et al. Eight-year change in body mass index and subsequent risk of cardiovascular disease among healthy non-smoking men. *Prev Med* 2007;45(6):436-41.

12.   Truesdale K, Stevens J, Lewis C, et al. Changes in risk factors for cardiovascular disease by baseline weight status in young adults who maintain or gain weight over 15 years: the CARDIA study. *Int J Obes (Lond)* 2006;30(9):1397-407.

13.   Mummery W, Schofield G, Steele R, et al. Occupational sitting time and overweight and obesity in Australian workers. *Am J Prev Med* 2005;29(2):91-7.

14.   Boyce RW, Boone EL, Cioci BW, et al. Physical activity, weight gain and occupational health among call centre employees. *Occup Med (Lond)* 2008;58(4):238-44.

15.   Sörensen L, Smolander J, Louhevaara V, et al. Physical activity, fitness and body composition of Finnish police officers: a 15-year follow-up study. *Occup Med (Lond)* 2000;50(1):3-10.

16.   Franke WD, Ramey SL, Shelley MC. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *J Occup Environ Med* 2002;44(12):1182-9.

17.   Franke WD, Collins SA, Hinz PN. Cardiovascular disease morbidity in an Iowa law enforcement cohort, compared with the general Iowa population. *J Occup Environ Med* 1998;40(5):441-4.

18.   Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

19.   Franke W, Anderson D. Relationship between physical activity and risk factors for cardiovascular disease among law enforcement officers. *J Occup Med* 1994;36(10):1127-32.

20.   Perry G, Byers T, Mokdad A, et al. The validity of self-reports of past body weights by U.S. adults. *Epidemiology* 1995;6(1):61-6.

21.   Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005;112(17):2735-52.

22.   Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications. Report of a WHO Consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus. Geneva: World Health Organization, 1999(WHO/NCD/NCS99.2).

23.   Wijndaele K, Beunen G, Duvigneaud N, et al. A continuous metabolic syndrome risk score: utility for epidemiological analyses. *Diabetes Care* 2006;29(10):2329.

24.   Gregg E, Gerzoff R, Thompson T, et al. Trying to lose weight, losing weight, and 9-year mortality in overweight U.S. adults with diabetes. *Diabetes Care* 2004;27(3):657-62.

25.   Kuczmarski R, Flegal K, Campbell S, et al. Increasing prevalence of overweight among US adults. The National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA* 1994;272(3):205-11.

26.   Galanis D, Harris T, Sharp D, et al. Relative weight, weight change, and risk of coronary heart disease in the Honolulu Heart Program. *Am J Epidemiol* 1998;147(4):379-86.

27. Oguma Y, Sesso H, Paffenbarger RJ, et al. Weight change and risk of developing type 2 diabetes. *Obes Res* 2005;13(5):945-51.

28. Williams L, Young A, Brown W. Weight gained in two years by a population of mid-aged women: how much is too much? *Int J Obes (Lond)* 2006;30(8):1229-33.

29. Norman J, Bild D, Lewis C, et al. The impact of weight change on cardiovascular disease risk factors in young black and white adults: the CARDIA study. *Int J Obes Relat Metab Disord* 2003;27(3):369-76.

30. Carnethon M, Loria C, Hill J, et al. Risk factors for the metabolic syndrome: the Coronary Artery Risk Development in Young Adults (CARDIA) study, 1985-2001. *Diabetes Care* 2004;27(11):2707-15.

31. Black E, Holst C, Astrup A, et al. Long-term influences of body-weight changes, independent of the attained weight, on risk of impaired glucose tolerance and Type 2 diabetes. *Diabet Med* 2005;22(9):1199-205.

32. Sonne-Holm S, Sørensen T, Jensen G, et al. Independent effects of weight change and attained body weight on prevalence of arterial hypertension in obese and non-obese men. *BMJ* 1989;299(6702):767-70.

33. Wannamethee S, Shaper A, Lennon L, et al. Metabolic syndrome vs Framingham Risk Score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Arch Intern Med* 2005;165(22):2644-50.

Table 1. The weight history of the study participants based on years of experience as a law enforcement officer

	Total (n = 415)	Years of experience as a LEO 1 – 5 (n = 88)	6–10 (n = 70)	11–15 (n = 101)	16–20 (n = 70)	>20 (n = 86)	F ratio or χ^2	P for Trend
Age (yrs)	37.6 ± 9.3 (19 – 59)	25.7 ± 3.7	32.5 ± 3.8	37.4 ± 4.2	43.2 ± 4.7	49.7 ± 4.2	427.0840	<0.0001
Academy BMI (kg/m^2)	24.5 ± 2.5 (18.5 – 31.0)	25.4 ± 2.6	24.3 ± 2.3	24.1 ± 2.6	24.3 ± 2.5	24.3 ± 2.3	4.0218	0.0033
Current BMI (kg/m^2)	28.4 ± 3.9 (19.3 – 43.8)	26.6 ± 2.9	27.6 ± 3.0	28.5 ± 4.2	29.4 ± 3.9	30.0 ± 4.2	11.3130	<0.0001
Weight gain since Academy (kg)	12.7 ± 10.1 (-8.6 – 52.7)	3.8 ± 3.7	11.0 ± 6.9	14.1 ± 9.9	16.4 ± 9.3	18.4 ± 11.5	36.4178	<0.0001
Weight gain per year (kg)	1.4 ± 1.6 (-2.5 – 8.8)	2.9 ± 2.6	1.3 ± 0.9	1.1 ± 0.8	0.9 ± 0.5	0.7 ± 0.4	36.9384	<0.0001
Academy BMI groups							13.290	0.1023
Normal	241 (58.1)	41 (46.6)	43 (61.4)	65 (64.4)	42 (60.0)	50 (58.1)		
Overweight	172 (41.5)	45 (51.1)	27 (38.6)	36 (35.6)	28 (40.0)	36 (41.9)		
Obese	2 (0.5)	2 (2.3)	0	0	0	0		
Current BMI groups							41.501	<0.0001
Normal	85 (20.5)	27 (30.7)	14 (20.0)	23 (22.8)	10 (14.3)	11 (12.8)		
Overweight	201 (48.4)	53 (60.2)	39 (55.7)	47 (46.5)	27 (38.6)	35 (40.7)		
Obese	129 (31.1)	8 (9.1)	17 (24.3)	31 (30.7)	33 (47.1)	40 (46.5)		

Values are mean ± SD or n (%)
Abbreviations: LEO, law enforcement officer; BMI, body mass index; Academy, police academy

Table 2. The descriptive characteristics of the study participants according to the weight gain per year category

	Total (n = 315)	Weight Gain Category (kg/yr)				F ratio	P for Trend
		<0.5 (n = 65)	0.5 to <1.0 (n = 114)	1.0 to <1.5 (n = 72)	≥1.5 (n = 64)		
Age (yrs)	40.7 ± 7.5 (25 – 59)	43.6 ± 7.3	42.5 ± 7.4	39.3 ± 6.9 *	36.2 ± 6.2 *	15.9906	<0.0001
Academy weight(kg)	78.8 ± 10.8 (49.0 – 121.3)	78.9 ± 12.5	77.3 ± 9.8	79.5 ± 9.2	80.9 ± 11.9	1.6855	0.1700
Current weight (kg)	94.6 ± 15.0 (50.9 – 153.8)	84.8 ± 13.5	90.7 ± 11.2 *	99.2 ± 12.4 *	106.4 ± 15.8 *	36.4352	<0.0001
Academy BMI	24.3 ± 2.4 (18.5 – 29.8)	24.3 ± 2.4	24.1 ± 2.4	24.4 ± 2.5	24.3 ± 2.4	0.2346	0.8722
Current BMI	29.1 ± 3.9 (19.3 – 43.8)	26.1 ± 2.8	28.3 ± 2.8 *	30.5 ± 3.9 *	32.0 ± 3.9 *	40.6161	<0.0001
Weight gain since academy (kg)	15.8 ± 9.5 (0 – 52.7)	5.9 ± 3.5	13.4 ± 5.5 *	19.7 ± 8.4 *	25.5 ± 8.8 *	104.4623	<0.0001
Years as a LEO (yrs)	16.7 ± 7.1 (6 – 37)	18.5 ± 7.4	18.4 ± 7.4	15.9 ± 6.5	12.7 ± 5.3 *	11.4910	<0.0001
Mean SBP (mmHg)	126.6 ± 10.6 (102 – 158)	124.2 ± 9.6	125.4 ± 10.2	129.2 ± 12.0 *	128.1 ± 9.8	3.5697	0.0145
Mean DBP (mmHg)	86.0 ± 8.0 (59 – 112)	84.1 ± 8.0	86.0 ± 7.7	87.1 ± 8.7	86.8 ± 7.7	1.8428	0.1393
MAP (mmHg)	99.5 ± 8.1 (75.3 – 123)	97.5 ± 7.8	99.1 ± 7.7	101.1 ± 8.9 *	100.5 ± 7.6	2.8232	0.0390
Triglycerides (mg/dL)	144.8 ± 95.6 (41 – 928)	122.8 ± 61.7	126.2 ± 67.1	156.2 ± 107.0	187.7 ± 132.6 *	7.6772	<0.0001

Table 2. (Continued)

| | Total (n = 315) | Weight Gain Category (kg/yr) | | | | F ratio | P for Trend |
		<0.5 (n = 65)	0.5 to <1.0 (n = 114)	1.0 to <1.5 (n = 72)	≥1.5 (n = 64)		
HDL-C (mg/dL)	47.0 ± 11.1 (24 – 110)	51.0 ± 13.6	48.6 ± 10.9	45.4 ± 9.1 *	41.8 ± 8.4 *	9.6046	<0.0001
Glucose (mg/dL)	93.0 ± 9.9 (48 – 149)	90.8 ± 7.8	93.2 ± 10.0	95.4 ± 11.8 *	92.4 ± 8.8	2.5669	0.0546
zMS	0.2 ± 3.2 (-8.8 – 17.2)	-2.0 ± 2.8	-0.6 ± 2.5 *	1.4 ± 3.3 *	2.4 ± 2.9 *	32.2322	<0.0001
zMMS	0.1 ± 2.6 (-7.1 – 15.7)	-1.2 ± 2.4	-0.4 ± 2.2	0.9 ± 2.9 *	1.4 ± 2.5 *	16.3037	<0.0001
MS presence	107 (34.0)	14 (21.5)	35 (30.7)	28 (38.9)	30 (46.9)	10.550	0.0144
MMS presence	68 (21.6)	11 (16.9)	19 (16.7)	20 (27.8)	18 (28.1)	5.712	0.1265
High physical activity	93 (29.5)	26 (40.0)	39 (34.2)	12 (16.7)	16 (25.0)	12.819	0.0460
Current smoking	47 (14.9)	8 (12.3)	21 (18.4)	8 (11.1)	10 (15.6)	3.343	0.7648

Values are mean ± standard deviation (range) or number (%).
Abbreviations: Academy, police academy; BMI, body mass index; LEO, law enforcement office; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; HDL, high density lipoprotein; zMS, the metabolic syndrome z-score; zMMS; the modified metabolic syndrome score without body mass index component; MS, the metabolic syndrome; MMS, the modified metabolic syndrome
*Significantly different from weight gain category <0.5 kg/yr at 0.05 level

Table 3. The odds ratio of the metabolic syndrome and its components in relation to weight gain category

	Odds ratio (95% Confidence interval)			
	Weight Gain Category (kg/year)			
	<0.5	0.5 – <1.0	1.0 – <1.5	≥1.5
Model a				
MS	1.0	2.11 (0.96 – 4.63)	5.51 (2.28 – 13.34)	13.48 (5.07 – 35.83)
MMS	1.0	1.10 (0.47 – 2.58)	3.35 (1.35 – 8.27)	4.95 (1.85 – 13.19)
Blood Pressure	1.0	1.29 (0.68 – 2.47)	2.14 (1.02 – 4.51)	3.50 (1.55 – 7.91)
Triglycerides	1.0	0.97 (0.51 – 1.87)	1.63 (0.79 – 3.38)	3.62 (1.65 – 7.96)
HDL cholesterol	1.0	1.44 (0.65 – 3.18)	2.09 (0.89 – 4.94)	5.50 (2.28 – 13.28)
Glucose	1.0	1.80 (0.76 – 4.30)	3.87 (1.48 – 10.13)	4.11 (1.41 – 12.00)
Model b				
MS	1.0	2.15 (0.94 – 4.92)	5.69 (2.21 – 14.65)	14.84 (5.24 – 42.05)
MMS	1.0	1.08 (0.45 – 2.60)	3.41 (1.32 – 8.83)	5.08 (1.84 – 14.08)
Blood Pressure	1.0	1.07 (0.54 – 3.12)	1.76 (0.80 – 3.87)	3.31 (1.40 – 7.86)
Triglycerides	1.0	0.88 (0.44 – 1.75)	1.62 (0.75 – 3.53)	3.65 (1.59 – 8.40)
HDL cholesterol	1.0	1.44 (0.64 – 3.26)	1.84 (0.75 – 4.52)	5.41 (2.16 – 13.51)
Glucose	1.0	1.83 (0.76 – 4.44)	3.80 (1.41 – 10.24)	4.17 (1.40 – 12.42)
Model c				
MS	1.0	1.02 (0.41 – 2.52)	0.98 (0.31 – 3.07)	1.53 (0.42 – 5.60)
MMS	1.0	0.81 (0.33 – 2.01)	1.65 (0.55 – 4.97)	1.86 (0.52 – 6.69)
Blood Pressure	1.0	0.67 (0.32 – 1.39)	0.65 (0.26 – 1.65)	0.80 (0.27 – 2.38)
Triglycerides	1.0	0.73 (0.36 – 1.50)	1.08 (0.44 – 2.65)	2.06 (0.73 – 5.83)
HDL cholesterol	1.0	1.08 (0.46 – 2.52)	0.94 (0.33 – 2.65)	2.15 (0.68 – 6.80)
Glucose	1.0	1.45 (0.58 – 3.63)	2.11 (0.66 – 6.77)	1.88 (0.47 – 7.47)

a. Controlled for age
b. Controlled for age, race, gender, exercise history and smoking history
c. Controlled for age, race, gender, exercise history, smoking history, and current body mass index
Abbreviations: MS, the metabolic syndrome; MMS, the modified metabolic syndrome; HDL, high density lipoprotein;

Table 4. Correlations among weight related variables and the metabolic syndrome score

	Current Weight (kg)	Academy BMI	Current BMI	Weight gain since academy	Weight gain per year	Years of experience as a LEO	Age	zMS	zMMS
Academy Weight (kg)	0.7791 *	0.8062 *	0.5071 *	0.0983	0.0795	0.0310	0.0588	0.4444 *	0.3561 *
Current Weight (kg)		0.6139 *	0.8539*	0.7004 *	0.4884 *	0.2263 *	0.1676 *	0.6666 *	0.5044 *
Academy BMI			0.6584 *	0.0567	0.0150	0.0364	0.0885	0.4674 *	0.3287 *
Current BMI				0.7783 *	0.5142 *	0.2659 *	0.2053 *	0.6905 *	0.4807 *
Weight gain since academy					0.6849 *	0.3240 *	0.1990 *	0.5522 *	0.3953 *
Weight gain per year						-0.3408 *	-0.3915 *	0.4533 *	0.3296 *
Years of experience as a LEO							0.8725 *	0.0572	0.0355
Age								0.0030	0.0019
zMS									0.9640 *

* Significant at 0.05 level.
Abbreviations: BMI, body mass index; LEO, law enforcement officer; zMS, the metabolic syndrome score,

Figure 1. A trend of weight history of study participants based on years of experience as a law enforcement officer
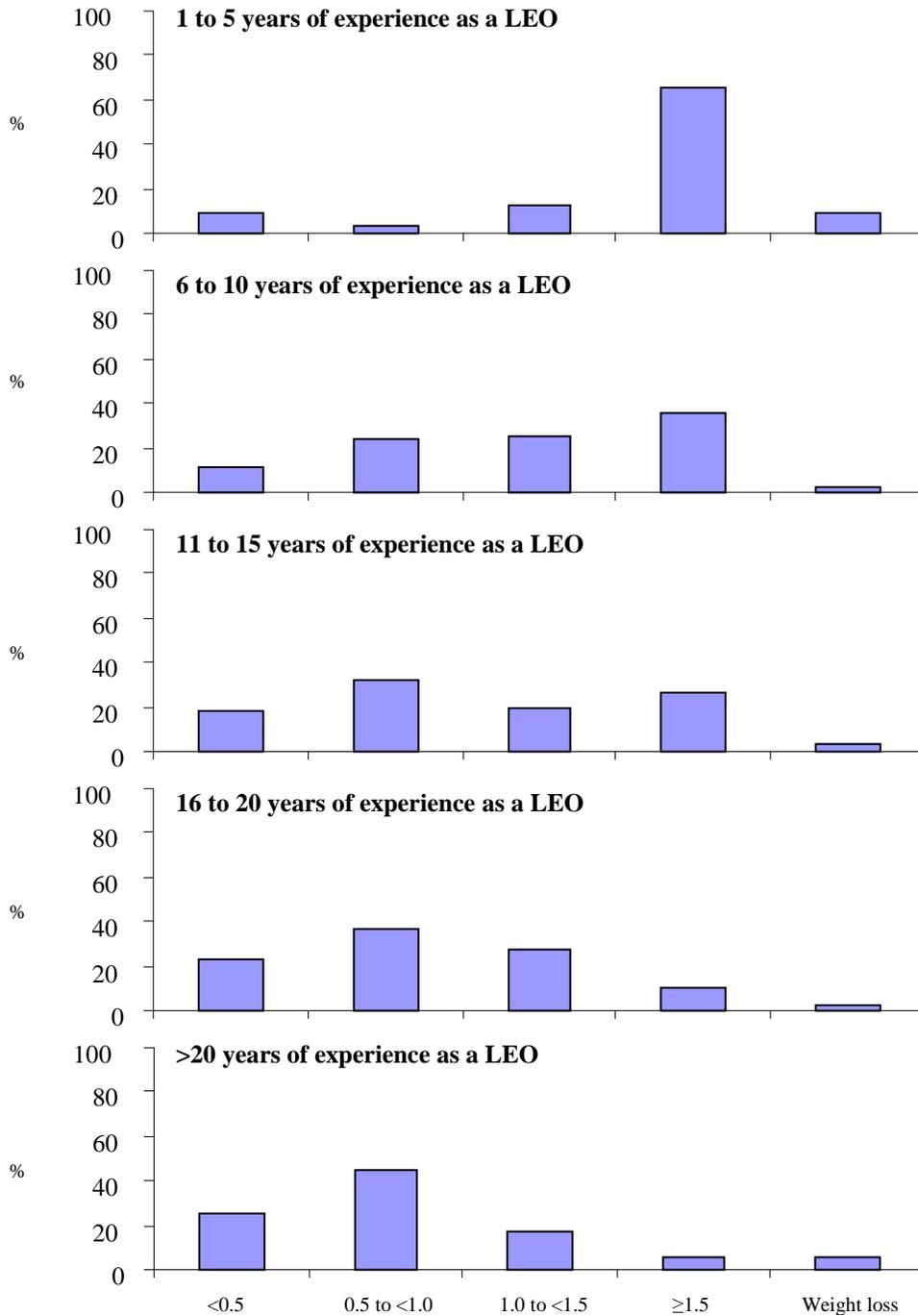
Acknowledgments

CHAPTER 5

LONGITUDINAL ANALYSIS OF POLICE STRESS AND THE METABOLIC SYNDROME

A manuscript to be submitted to

International Archives of Occupational and Environmental Health

Abstract

Objective: To assess and compare the change in the prevalence of the metabolic syndrome and its components over time (2001- 2007) and to determine whether changes in stress affect the metabolic health risk among police officers. **Methods**: Perceived Stress and metabolic risk factors were assessed in 171 police officers in 2001 and again in 2007. **Results**: The perceived stress score (PSS) and the metabolic syndrome score (zMS) were not meaningfully different from 2001 to 2007. The prevalence of high body mass index, hypertension, and elevated triglycerides increased from 2001 to 2007. Overall, the prevalence of the metabolic syndrome increased from 17.5% in 2001 to 28.7% in 2007. The PSS in 2007 was highly correlated with the PSS in 2001 ($r = 0.44$) and zMS in 2007 was strongly correlated with zMS in 2001 ($r = 68$). Neither the change in perceived stress over time nor baseline perceived stress predicted the development of the metabolic syndrome in 2007 among police officers. **Conclusion**: The prevalence of the metabolic syndrome and its several individual components increased over 6 years among LEOs. Stress as assessed by the PSS does not contribute to the development of metabolic health risk after a 6 year follow-up.

Introduction

Police work is perceived as highly demanding and stressful (1, 2). By the nature of their jobs, many police officers face significant work-related stressors on a daily basis. The traumatic aspects of police work, such as confronting death, violence, or exposure to physical injury, as well as the more routine aspects of police work such as shift changes, overtime duties, and feelings of always being on duty are common work-related stressors (1-4). Continuous exposure to work-related stress may alter the autonomic nervous and neuroendocrine systems that control reactions to stress (5). These two systems evoke stress-related cortisol secretion that contributes to the development of chronic diseases such as dyslipidemia, abdominal obesity, hypertension, and insulin resistance and further cardiovascular disease and the metabolic syndrome (6, 7).

The metabolic syndrome is a widely diagnosed medical disorder that has been increasing dramatically over the past few decades (8). It is characterized by a cluster of cardiometabolic abnormalities such as central obesity, dyslipidemia, hypertension, and glucose intolerance (9). The metabolic syndrome is a significant predictor of cardiovascular disease (CVD) and Type 2 diabetes (10). Chronic stress is associated with an increased risk of the metabolic syndrome (5) and can be an underlying cause of the metabolic syndrome by dysregulating the HPA axis (11).

Few studies have examined the metabolic syndrome in law enforcement officers (LEOs), such that the risk of the metabolic syndrome in the law enforcement profession has been debated. Some studies suggest that LEOs have a higher prevalence of the metabolic syndrome than the general population (12-15), while others suggest that LEOs have a similar or even a lower prevalence of the metabolic syndrome compared to the

general public (16, 17). However all these assessments were cross-sectional studies;

trends in the prevalence of the metabolic syndrome over time among LEOs have not been

assessed.

There is also no clear consensus of the association between stress and the

metabolic risk among LEOs. Franke and coworkers (18) showed that stress is associated

with CVD prevalence in police officers. However, Yoo and colleagues (16) found that

there is no significant association between stress and the metabolic syndrome in a LEO

cohort. Violanti and colleagues (17) also found that posttraumatic stress disorder was not

associated with the metabolic syndrome after controlling covariates in police officers.

Due to the cross-sectional nature of these studies, it is not possible to discern the causal

relationship between stress and the metabolic syndrome in LEOs.

Although a few cross-sectional studies have assessed the prevalence of the

metabolic syndrome (12-17) or the association between stress and the metabolic

syndrome (16, 18) in police officers, the effect of the change in the level of stress over

time on the metabolic syndrome, and the changes in the prevalence of the metabolic

syndrome and its individual components over time have not been assessed. In the

absence of longitudinal assessments, a causal relationship between stress and the

metabolic syndrome can not be inferred. To reduce CVD risk and further prevent the

premature death from chronic diseases in police officers, there is a marked need for

longitudinal studies on the metabolic syndrome among this unique occupational cohort.

Consequently, the purpose of this study was two-fold. The first purpose was to

assess and compare the change in the prevalence of the metabolic syndrome and its

components over time (2001- 2007) in police officers. The second purpose of this study

was to determine whether changes in stress affect the metabolic health risk among police

officers.

Methods

This is a longitudinal study which is part of an on-going project to assess health

and fitness in police officers resided in Iowa. LEOs who attended in annual medical

evaluation in 2001 were again invited in this study at a 6 year follow-up (i.e., in 2007).

Participants

Participants in this study were sworn LEOs from the Iowa Department of Public

Safety. Data collection was performed in conjunction with the officers' annual medical

evaluation. At baseline (2001), LEOs who attended the medical evaluation in that year (n

= 559) were invited to participate in the stress study. The participation rate was 98%

(546 participants). At follow-up of 2007, LEOs who participated in the stress study in

2001 were invited again. For both 2001 and 2007, the same measurements were

collected from participants. Among 546 LEOs who participated in 2001, 106 had retired

and another 121 did not participate in data collection, leaving 319 potential subjects for

this study. Of these 319, 187 provided complete data both in 2001 and 2007. Because of

limited sample sizes for females (n = 12) and other races (n = 4), only data from

Caucasian males were included in the statistical analysis (n = 171). Participants gave

written informed consent and completed questionnaires on socio-demographics, medical

history, physical activity history, and smoking history. All procedures were approved by

the Institutional Review Board of Iowa State University.

Measurements

Psychological Stress: Perceived stress was assessed using the Perceived Stress Scale (PSS), which measures the degree to which a person appraises situations in his or her life as stressful (19). It consists of 14 Likert-type items designed to assess how unpredictable, uncontrollable, and overloaded respondents perceive their lives to be. Scores can range from 0 to 56 and a lower score is indicative of lower perceived stress. The Perceived Stress Scale has been shown to be reliable and valid, with internal reliability as determined by Cronbach's α of 0.75 (20).

Metabolic Risk Factors: Systolic (SBP) and diastolic blood pressure (DBP) were measured in a seated position after 5 minutes rest using a standard mercury sphygmomanometer and auscultatory methods . Blood pressure was determined as the average of two readings. A 12-hour fasting blood sample was obtained by venipuncture. Serum triglycerides, high-density lipoprotein (HDL) cholesterol, and fasting plasma glucose were assayed with automated techniques at a laboratory which participates in and meets the quality control standards of the U.S. CDC Lipid Standardization Program (Quest Diagnostics, Wood Dale, IL). Height was measured with no shoes with a stadiometer (Seca, Hanover, Maryland) to the nearest 0.5 cm. Body mass was measured with light clothing and shoes on a digital scale (Befour, Inc, Saukville, WI) to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

The Metabolic syndrome: The metabolic syndrome was defined according to the American Heart Association and National Heart, Lung, and Blood Institute criteria (21). Instead of waist circumference, abdominal obesity was assessed according to the World

Health Organization definition by using a BMI ≥30 kg/m^2 (22). Therefore, the metabolic

syndrome in this study was defined by the presence of three or more of the following

risk factors: (1) BMI ≥30 kg/m^2; (2) blood pressure ≥130 mmHg systolic (SBP) or ≥85

mmHg diastolic (DBP) or both or currently using antihypertensive medications; (3)

serum triglycerides ≥150 mg/dL (≥1.70 mmol/L); (4) HDL cholesterol <40 mg/dL (<1.03

mmol/L) for males and <50 mg/dL (<1.29 mmol/L) for females; and (5) fasting plasma

glucose ≥100 mg/dL (≥5.6 mmol/L) or currently using antidiabetic medications.

A continuous, quantitative metabolic syndrome score was developed based on the

sum of age-standardized residuals (z-scores) for the metabolic syndrome (23). To

normalize for age-related differences in the risk factors, the individual metabolic

syndrome risk factors including BMI, mean arterial pressure (MAP; DBP+1/3[SBP-

DBP]), triglyceride, HDL cholesterol, and fasting plasma glucose, were regressed onto

age. The standardized HDL cholesterol was multiplied by -1 because HDL cholesterol is

inversely related to the metabolic syndrome. The individual z-scores were then summed

to create the metabolic syndrome score (zMS). A lower score was indicative of a better

metabolic syndrome risk factor profile.

Statistical Analysis

Data from 171 LEOs were used for the analyses. A paired-sampled t-test and χ^2

tests were used to compare the mean levels of continuous variables and the prevalence of

categorical variables in subject characteristics between year 2001 and 2007.

Pearson correlation coefficients between the PSS in 2001, the PSS in 2007, zMS

in 2001, and zMS in 2007 were calculated.

To measure the odds ratios for the incidence of the metabolic syndrome in 2007 depending on the change in PSS, LEOs who had the metabolic syndrome at the baseline exam (in 2001, n = 30) were excluded from further analysis. Thus, a total of 141 LEOs were included in this analysis.

LEOs were then categorized into three PSS change groups to assess the association of changes in perceived stress over time and resultant metabolic syndrome ; (1) Decreased – LEOs who experienced a decline in PSS from 2001 to 2007 of at least 2 units, , (2) Stable – LEOs with a PSS in 2007 that was within two units of their 2001 PSS score, and (3) Increased – LEOs who had a PSS in 2007 that was at least 2 units higher than that of 2001.

Logistic regression analysis was used to determine the odds ratios of having the metabolic syndrome in 2007 in the PSS change subgroups. The PSS Stable group was used as the reference category in all analysis. Covariates included age, smoking history (current, former, and never smoking), and physical activity history (low, moderate, or vigorous activity in the past 30 days).

To determine whether the change in PSS between 2001 and 2007 or PSS in 2001 predicted the risk of the metabolic syndrome after a 6 year follow-up, zMS in 2007 was regressed onto the following predictors: the change in PSS between 2001 and 2007, PSS in 2001, zMS in 2001, age, smoking history (current, former, and never smoking), and physical activity history (low, moderate, or vigorous activity in the past 30 days). All predictors were simultaneously entered into the regression model as a single block in order to determine whether the change in PSS between 2001 and 2007 or the PSS in 2001

was a valid predictor of the metabolic health risk in 2007, while controlling for all other variables.

Statistical significance was defined as $P < 0.05$. All statistical analyses were performed using either JMP (Version 8, SAS Institute Inc., Cary, NC) or the Statistical Package for Social Science (SPSS forWindows, version 17.0, SPSS Inc, Chicago, IL) program.

Results

The descriptive characteristics of the total study participants at baseline (in 2001) and at a 6 year follow-up (in 2007) are shown in Table 1. The age and years of experience of these 171 LEOs in 2007 were 40±7 and 16.2 ± 6.3 years, respectively. Body weight, BMI, and HDL cholesterol significantly increased from 2001 to 2007, and fasting glucose level was significantly decreased from 2001 to 2007 ($P < 0.05$ for all). Blood pressure, triglycerides, total cholesterol, low density lipoprotein (LDL) cholesterol, and zMS were not significantly different between 2001 and in 2007. The perceived stress score was not meaningfully different from 2001 to 2007. In 2007, there were more obese LEOs than in 2001 (32.1% vs. 22.8%), slightly more LEOs who met the physical activity recommendation (defined as participating regularly in vigorous physical activity for ≥60 minutes or in moderate physical activity for ≥150 minutes per week (24); 34.3% vs. 32.4%; $P = 0.7009$), and more LEOs who were currently tobacco users (17.0% vs. 4.7%; $P = 0.0002$).

Table 2 presents the prevalence of the metabolic syndrome and its components among LEOs in 2001 and in 2007 (n = 171). The most prevalent individual metabolic

syndrome component was hypertension both in 2001 and in 2007 (43.9% and 60.8%, respectively). The least prevalent individual component was high BMI in 2001 (19.9%) and elevated fasting glucose in 2007 (15.8%). The prevalence of high BMI and hypertension increased significantly from 2001 to 2007 ($P <0.05$ for all). In contrast, the prevalence of low HDL cholesterol and high fasting glucose decreased significantly from 2001 to 2007 ($P <0.05$ for all). Overall, the prevalence of the metabolic syndrome increased significantly from 17.5% in 2001 to 28.7% in 2007 ($P = 0.0144$). The number of the metabolic syndrome components in each LEO increased from 1.5 in 2001 to 1.7 in 2007.

Table 3 illustrates the correlations among the PSS and zMS in LEOs (n = 171). The PSS in 2007 was highly correlated with the PSS in 2001 ($r = 0.44$) and zMS in 2007 was strongly correlated with zMS in 2001 ($r = 68$). Regression analyses showed that neither the change in PSS between 2001 and 2007 nor the PSS in 2001 was related to zMS in 2007 (data not shown).

Table 4 presents crude and adjusted odd ratios of the incidence of the metabolic syndrome in 2007 for the PSS change groups. In 2007, 33 new incidences of the metabolic syndrome occurred among 141 LEOs. The odds ratios of the metabolic syndrome for the PSS loss and gain groups were not significantly different than for the PSS stable group.

Discussion

The metabolic syndrome is receiving increased attention. Police officers may be at increased risk of the metabolic syndrome. However, to date, data on its prevalence and

the underlying risk factors in LEOs are very limited. Moreover, almost all the relevant studies employed cross-sectional designs. The cross-sectional nature permits neither tracking trends of metabolic syndrome risk over time nor discerning causal relationships between risk factors and the metabolic syndrome. To begin to reduce the metabolic syndrome-related mortality and morbidity in police officers, studies with the longitudinal data on the prevalence and risk factors of the metabolic syndrome among this unique occupational cohort are needed.

The purpose of the current study was to examine 1) the change in the prevalence of the metabolic syndrome and its components over time (2001- 2007) and 2) whether the change in stress over a 6 year time period predicted the metabolic health risk among police officers. This study found that the prevalence of the metabolic syndrome and its several individual components increased over 6 years among LEOs. However, neither baseline perceived stress nor the change in perceived stress between 2001 and 2007 predicted the development of the metabolic syndrome in 2007 among police officers.

Our results showed that body weight and BMI significantly increased from 2001 to 2007; however, the levels of SBP, DBP, triglycerides, total cholesterol, and LDL cholesterol in 2007 are not significantly different than those in 2001. Furthermore, profiles of HDL cholesterol and fasting glucose were somewhat improved from 2001 to 2007, despite the increase in body weight. Attained body weight is an important risk factor for diabetes (25), and BMI independently influences HDL cholesterol concentration (26). We speculate that these trends may be due to an increased intake of medications that control for blood pressure, blood lipids and glucose, among LEOs in 2007 compared to in 2001. Use of medications to control dyslipidemia, hypertension,

and high fasting glucose increased more than 250% from 2001 to 2007 among participated LEOs (data not shown).

A significant portion of LEOs have an increased prevalence of several conventional CVD risk factors such as hypertension, hypercholesterolemia, obesity, and diabetes (18, 27, 28). However, conventional risk factors do not fully explain the increase in CVD seen in LEOs, thus nor probably in the metabolic syndrome. The 10-year risk for developing CVD using conventional CVD risk factors in LEOs does not significantly differ from the general population (29, 30). Furthermore, retired LEOs had as much as a 1.7 times higher prevalence of CVD than the general population of similar age even after controlling for conventional risk factors (27). Therefore, risk factors that were not accounted for or unique characteristics of this occupation of law enforcement may explain an increased risk for the metabolic syndrome seen in LEOs.

Work stress has been linked with CVD (31-33) as well as components of the metabolic syndrome (6, 7, 34-36). Recent studies suggest that stress at work may influence the pathogenesis of the metabolic syndrome (5, 36, 37). Chandola and coworkers (5) conducted a prospective cohort study with an average of 14 years of follow-up on 10,308 men and women. This study found that employees with chronic work stress are more than twice as likely to have the metabolic syndrome than those without stress at work, after controlling for age and employment grade (odd ratio [OR] = 2.25, 95% CI = 1.31 – 3.85).

Although the biological mechanisms underlining this association are not completely understood, prolonged exposure to work stress may affect the autonomic nervous system and neuroendocrine responses that can contribute to the development of

the metabolic syndrome (5). Neuroendocrine responses to stress activate the HPA axis, resulting in the secretion of steroid hormones, including corticosteroids and catecholamines, which are major stress hormones (38). Cortisol is a corticosteroid hormone which is secreted from the adrenal cortex under the control of the HPA axis (38). During short-term acute stress, plasma cortisol levels are elevated by the activation of the HPA axis for survival through homeostatic adjustments (39). However, frequent chronic stress may sustain elevated cortisol secretion that may cause damage to the HPA axis with time, resulting in a maladaptive process (40, 41). Stress-related cortisol secretion has been linked with individual components of the metabolic syndrome. For example, stress-dependent cortisol values are strongly associated with abdominal obesity, glucose, triglycerides, HDL cholesterol, and systolic and diastolic blood pressure (6, 7, 36).

Policing is perceived as a highly stressful occupation (1, 2). It is recognized as one of the most stressful occupations in the world (42). Thus, we hypothesized that there would be a causal relationship between stress and the metabolic syndrome in LEOs. The present data do not support this hypothesis. Indeed, the mean perceived stress levels of the LEOs (mean PSS = 18.1, standard deviation [SD] = 5.8 in 2001 and mean PSS = 17.2, SD = 6.6 in 2007, respectively) were not markedly elevated when compared to the mean score of U.S. males and females, 18 years of age and older (mean PSS = 19.6, SD = 7.5) (20).

In previous studies, the Perceived Stress Scale has been used effectively involving police officers. For example, Hills and Norvell (43) suggested that the PSS is a significant and important predictor of stress-induced consequences, including burnout,

physical symptoms, and job dissatisfaction in highway patrol officers. In addition,

Franke et al. (18) found that high PSS was associated with CVD risk in employed police

officers. In contrast, however, Yoo and colleagues (16) found that the PSS was not

significantly associated with the metabolic syndrome in a LEO cohort ($r = 0.047$).

Although the results of each study were different, these studies commonly used the cross-

sectional study design. The current study, however, used a longitudinal study design to

assess the causal relationship between the perceived stress and the metabolic syndrome.

The results of the current study show that perceived stress at baseline and the change in

perceived stress over 6 years time are not important contributors to the development of

the metabolic syndrome in LEOs.

Limitations of the present study warrant discussion. First, our study only included

Caucasian male LEOs. Thus, the results of this study may not be representative of the

broader LEO population. Second, perceived stress was measured by self-report. Self-

reported stress measurement may not measure the physiological stress status, thus errors

in self-reported stress measurement may confound the analyses between stress and the

metabolic syndrome. Third, this study used BMI ≥ 30 kg/m^2 instead of waist

circumference to assess the abdominal component of the metabolic syndrome definition,

because waist circumference was not directly measured in this study. Although BMI is

conveniently and widely used to determine obesity in a population study, this

measurement does not assess body composition *per se*. Muscle mass, abdominal fat

mass, and body fat distribution can vary largely within a narrow range of BMI (44).

Nevertheless, a BMI of 28.9 kg/m^2 is approximately equivalent to a waist circumference

of 102 cm (10). Thus, a BMI $\geq$30 kg/m^2 was a relatively conservative estimate of

obesity.

In conclusion, the results of this study suggest that stress does not contribute to

the development of metabolic health risk after a 6 year follow-up among police officers.

References

1. Gershon RR, Lin S, Li X. Work stress in aging police officers. *J Occup Environ Med* 2002;44(2):160-7.

2. Kop N, Euwema MC. Occupational stress and the use of force by Dutch police officers. *Criminal Justice and Behaviour* 2001;28:631-52.

3. Violanti JM, Aron F. Ranking police stressors. *Psychol Rep* 1994;75(2):824-6.

4. Kirkcaldy B, Cooper C, Ruffalo P. Work stress and health in a sample of U.S. police. *Psychol Rep* 1995;76(2):700-2.

5. Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. *BMJ* 2006;332(7540):521-5.

6. Björntorp P, Rosmond R. Hypothalamic origin of the metabolic syndrome X. *Ann N Y Acad Sci* 1999;892:297-307.

7. Rosmond R, Björntorp P. The hypothalamic-pituitary-adrenal axis activity as a predictor of cardiovascular disease, type 2 diabetes and stroke. *J Intern Med* 2000;247(2):188-97.

8. Ford E, Giles W, Mokdad A. Increasing prevalence of the metabolic syndrome among u.s. Adults. *Diabetes Care* 2004;27(10):2444-9.

9. Grundy SM, Brewer HB, Jr., Cleeman JI, et al. Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 2004;109(3):433-8.

10. Wannamethee S, Shaper A, Lennon L, et al. Metabolic syndrome vs Framingham Risk Score for prediction of coronary heart disease, stroke, and type 2 diabetes mellitus. *Arch Intern Med* 2005;165(22):2644-50.

11. Gohil B, Rosenblum L, Coplan J, et al. Hypothalamic-pituitary-adrenal axis function and the metabolic syndrome X of obesity. *CNS Spectr* 2001;6(7):581-6, 9.

12. Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

13. Chandramohan P, Mohan V. High prevalence of diabetes and metabolic syndrome among policemen. *J Assoc Physicians India* 2008;56:837-9.

14. Humbarger C, Crouse S, Womack J, et al. Frequency of metabolic syndrome in police officers compared to NCEP III prevalence values. *Med Sci Sports Exerc* 2004;36(5):S161.

15. Bos M, de Vries J, Wolffenbuttel B, et al. [The prevalence of the metabolic syndrome in the Netherlands: increased risk of cardiovascular diseases and diabetes mellitus type 2 in one quarter of persons under 60]. *Ned Tijdschr Geneeskd* 2007;151(43):2382-8.

16. Yoo HL, Eisenmann JC, Franke WD. Independent and Combined Influence of Physical Activity and Perceived Stress on the Metabolic Syndrome in Male Law Enforcement Officers. *J Occup Environ Med* 2009;51(1):46-53.

17. Violanti J, Fekedulegn D, Hartley T, et al. Police trauma and cardiovascular disease: association between PTSD symptoms and metabolic syndrome. *Int J Emerg Ment Health* 2006;8(4):227-37.

18. Franke WD, Ramey SL, Shelley MC. Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. *J Occup Environ Med* 2002;44(12):1182-9.

19. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24(4):385-96.

20. Cohen S, Williamson G. *Perceived stress in a probability sample of the United States*. Newbury Park, CA: Sage; 1988.

21. Grundy SM, Cleeman JI, Daniels SR, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation* 2005;112(17):2735-52.

22. Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications. Report of a WHO Consultation. Part 1: Diagnosis and Classification of Diabetes Mellitus. Geneva: World Health Organization, 1999(WHO/NCD/NCS99.2).

23.   Wijndaele K, Beunen G, Duvigneaud N, et al. A continuous metabolic syndrome risk score: utility for epidemiological analyses. *Diabetes Care* 2006;29(10):2329.

24.   Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;39(8):1423-34.

25.   Brancati F, Wang N, Mead L, et al. Body weight patterns from 20 to 49 years of age and subsequent risk for diabetes mellitus: the Johns Hopkins Precursors Study. *Arch Intern Med* 1999;159(9):957-63.

26.   Bernard S, Moulin P, Lagrost L, et al. Association between plasma HDL-cholesterol concentration and Taq1B CETP gene polymorphism in non-insulin-dependent diabetes mellitus. *J Lipid Res* 1998;39(1):59-65.

27.   Franke WD, Collins SA, Hinz PN. Cardiovascular disease morbidity in an Iowa law enforcement cohort, compared with the general Iowa population. *J Occup Environ Med* 1998;40(5):441-4.

28.   Balkau B, Shipley M, Jarrett R, et al. High blood glucose concentration is a risk factor for mortality in middle-aged nondiabetic men. 20-year follow-up in the Whitehall Study, the Paris Prospective Study, and the Helsinki Policemen Study. *Diabetes Care* 1998;21(3):360-7.

29.   Franke W, Cox D, Schultz D, et al. Coronary heart disease risk factors in employees of Iowa's Department of Public Safety compared to a cohort of the general population. *Am J Ind Med* 1997;31(6):733-7.

30.   Franke W, Kohut M, Russell D, et al. Is job-related stress the link between cardiovascular disease and the law enforcement profession? *J Occup Environ Med* 2010;52(5):561-5.

31.   Rosengren A, Hawken S, Ounpuu S, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364(9438):953-62.

32.   Marmot M, Bosma H, Hemingway H, et al. Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet* 1997;350(9073):235-9.

33.   Peter R, Siegrist J. Chronic psychosocial stress at work and cardiovascular disease: the role of effort-reward imbalance. *Int J Law Psychiatry* 1999;22(5-6):441-9.

34.   Siegrist J, Peter R, Cremer P, et al. Chronic work stress is associated with atherogenic lipids and elevated fibrinogen in middle-aged men. *J Intern Med* 1997;242(2):149-56.

35.   Peter R, Alfredsson L, Hammar N, et al. High effort, low reward, and cardiovascular risk factors in employed Swedish men and women: baseline results from the WOLF Study. *J Epidemiol Community Health* 1998;52(9):540-7.

36.   Rosmond R, Dallman M, Björntorp P. Stress-related cortisol secretion in men: relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. *J Clin Endocrinol Metab* 1998;83(6):1853-9.

37.   Steptoe A, Brunner E, Marmot M. Stress-induced inflammatory responses and risk of the metabolic syndrome: a longitudinal analysis. *Obes Res* 2004;12:A76.

38.   Black P, Garbutt L. Stress, inflammation and cardiovascular disease. *J Psychosom Res* 2002;52(1):1-23.

39.   Walker B. Cortisol--cause and cure for metabolic syndrome? *Diabet Med* 2006;23(12):1281-8.

40.   Dallman M. Stress update Adaptation of the hypothalamic-pituitary-adrenal axis to chronic stress. *Trends Endocrinol Metab* 1993;4(2):62-9.

41.   McEwen B. Protective and damaging effects of stress mediators. *N Engl J Med* 1998;338(3):171-9.

42.   Selye H. Police stress. *Police Stress Magazine* 1984;1:2-5.

43.   Hills H, Norvell N. An examination of hardiness and neuroticism as potential moderators of stress outcomes. *Behav Med* 1991;17(1):31-8.

44.   World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation presented at: the World Health Organization. Geneva, Switzerland, June 3-5, 1997.

Table 1. The descriptive characteristics of the total study participants at baseline (in 2001) and at a 6 year follow-up (in 2007) (n = 171)

	Year		t or χ^2	P
	2001	2007		
Age (yrs)	34.3 ± 6.8	40.3 ± 6.8		
Years as a LEO (yrs)	10.2 ± 6.3	16.2 ± 6.3		
Weight (kg)	90.5 ± 13.3	93.2 ± 14.1	5.2564	<0.0001
Body mass index (kg/m^2)	27.8 ± 3.4	28.6 ± 3.7	5.2561	<0.0001
Systolic blood pressure (mmHg)	125.1 ± 8.5	126.3 ± 10.5	1.6170	0.1077
Diastolic blood pressure (mmHg)	84.0 ± 7.6	85.3 ± 8.1	1.8171	0.0710
Mean arterial pressure (mmHg)	97.7 ± 7.4	99.0 ± 8.1	1.9511	0.0527
Triglycerides (mg/dL)	133.0 ± 70.9	130.8 ± 65.2	-0.4582	0.6474
Total Cholesterol (mg/dL)	196.0 ± 38.3	197.2 ± 32.1	0.4648	0.6427
HDL cholesterol (mg/dL)	43.9 ± 8.5	47.7 ± 11.1	6.5629	<0.0001
LDL cholesterol (mg/dL)	126.3 ± 31.8	123.3 ± 27.5	-1.3546	0.1773
Glucose (mg/dL)	95.0 ± 9.5	92.8 ± 8.3	-3.2161	0.0016
zMS	-0.0 ± 2.8	-0.1 ± 2.9	-0.5233	0.6014
Perceived stress score	18.1 ± 5.8	17.2 ± 6.6	-1.7921	0.0749
Body mass index groups			3.7888	0.1504
Normal	32 (18.7)	29 (17.0)		
Overweight	100 (58.5)	87 (50.9)		
Obese	39 (22.8)	55 (32.1)		
Physical activity groups			0.1475	0.7009
Above recommendation*	55 (32.4)	58 (34.3)		
Tobacco status			14.1062	0.0002
Current use	8 (4.7)	29 (17.0)		

Values are mean ± standard deviation or number (%)
Abbreviations: LEO, law enforcement officer; HDL, high density lipoprotein; LDL, low density lipoprotein; zMS, the metabolic syndrome score
* Defined as participating regularly in vigorous physical activity for ≥60 minutes or in moderate physical activity for ≥150 minutes per week

Table 2. The prevalence of the metabolic syndrome and its components among the total study participants in 2001 and in 2007 (n = 171)

	Year		χ^2	P
	2001	2007		
Individual metabolic syndrome components				
High body mass index ($\geq$30 kg/m^2)	34 (19.9)	55 (32.2)	6.7472	0.0094
Hypertension (SBP $\geq$130 mmHg, DBP $\geq$85 mmHg, or antihypertensive medication use)	75 (43.9)	104 (60.8)	9.9062	0.0016
Reduced HDL cholesterol (<40 mg/dL in males, <50 mg/dL in females)	60 (35.1)	37 (21.6)	7.6683	0.0056
Elevated triglycerides ($\geq$150 mg/dL)	52 (30.4)	68 (39.8)	3.2939	0.0695
Eleavted fasting glucose ($\geq$100 mg/dL or diabetic medication use)	42 (24.6)	27 (15.8)	4.1116	0.0426
Presence of the metabolic syndrome	30 (17.5)	49 (28.7)	5.9885	0.0144
Number of the metabolic syndrome components	1.5 $\pm$ 1.2	1.7 $\pm$ 1.3		

Values are number (%) or mean $\pm$ standard deviation
Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high density lipoprotein; LDL

Table 3. Correlations among the perceived stress score and the metabolic syndrome score (n = 171)

	PSS in 2001	PSS in 2007	zMS in 2001
PSS in 2007	0.4449*		
zMS in 2001	-0.0585	-0.0315	
zMS in 2007	-0.0691	-0.1478	0.6828*

Abbreviations: PSS, perceived stress score; zMS, the metabolic syndrome score
*Significant at 0.05 level.

Table 4. Crude and adjusted odds ratios for the metabolic syndrome with different perceived stress score change groups (n = 141)

PSS change category	Odds ratio (95% confidence interval)	
	Univariate model	Multivariate model*
Loss	1.12 (0.43 – 2.93)	0.98 (0.36 – 2.69)
Stable	1.0	1.0
Gain	1.53 (0.56 – 4.20)	1.49 (0.52 – 4.29)

* Adjusted for age, smoking history, and exercise history
Abbreviation: PSS, the perceived stress score

Acknowledgments

CHAPTER 6

GENERAL CONCLUSIONS

This dissertation consists of a series of manuscripts which focus on the association between risk factors of the metabolic syndrome and the metabolic health risk among law enforcement officers (LEOs). The metabolic syndrome has received increased attention in the past few years. Previous work suggested that LEOs may be at a greater risk for the metabolic syndrome (1-3); however, the risk factors for the metabolic syndrome in this specific occupation have not been fully examined.

The first manuscript (Association of physical activity and obesity to the risk of the metabolic syndrome in police officers) suggests that both lower levels of physical activity and higher body mass index (BMI) are strongly associated with an increased risk for the metabolic syndrome in police officers. High BMI is positively associated with the metabolic syndrome independent of physical activity. However, the association between physical activity and the metabolic syndrome is weakened markedly after consideration of BMI. While BMI showed stronger effects on the association with the metabolic syndrome than physical activity, higher physical activity showed favorable metabolic risk scores within BMI categories.

The findings of the second manuscript (Weight gain and the metabolic syndrome in police officers) suggest that increasing weight gain is significantly associated with an increased risk of the metabolic syndrome and its individual components. However, this association is not independent of the current BMI among LEOs, suggesting that the

attained BMI has a greater influence on the metabolic health risk than weight gain in adulthood.

To the best of our knowledge, the third manuscript (Longitudinal analysis of police stress and the metabolic syndrome) was the first to utilize a longitudinal design to assess the change in the prevalence of the metabolic syndrome and its components over time (2001- 2007) and whether a base-line level of stress predicts the metabolic health risk after a six year follow-up in police officers. The results of this study suggest that LEOs have an increased prevalence of the metabolic syndrome with age and stress does not predict the development of the metabolic syndrome after a six year follow-up among LEOs.

In summary, these data suggest that LEOs who are overweight or obese, physically inactive, or gaining more weight are at greater risk for the metabolic syndrome and its individual components than other LEOs. Weight control and regular physical activity should be encouraged for LEOs to maintain an optimal BMI and to reduce the metabolic syndrome-related morbidity and mortality. Finally, the prevalence of the metabolic syndrome in this LEO cohort does not appear to be increased above that of the general population (present work; (4)).

References

1. Humbarger C, Crouse S, Womack J, et al. Frequency of metabolic syndrome in police officers compared to NCEP III prevalence values. *Med Sci Sports Exerc* 2004;36(5):S161.

2. Tharkar S, Kumpatla S, Muthukumaran P, et al. High prevalence of metabolic syndrome and cardiovascular risk among police personnel compared to general population in India. *J Assoc Physicians India* 2008;56:845-9.

3. Bos M, de Vries J, Wolffenbuttel B, et al. [The prevalence of the metabolic syndrome in the Netherlands: increased risk of cardiovascular diseases and diabetes mellitus type 2 in one quarter of persons under 60]. *Ned Tijdschr Geneeskd* 2007;151(43):2382-8.

4. Yoo HL, Eisenmann JC, Franke WD. Independent and Combined Influence of Physical Activity and Perceived Stress on the Metabolic Syndrome in Male Law Enforcement Officers. *J Occup Environ Med* 2009;51(1):46-53.

APPENDIX A. PHYSICAL ACTIVITY QUESTIONNAIRE

EXERCISE AND FITNESS

EF1 Read the descriptions below, and check the one (0 to 7) which best describes
Your general physical activity during the past month **(Mark only one.)**

General Description	Mark One	Specific Level Descriptions
I do not participate regularly in programmed recreation, sport or heavy physical labor.	Level 0:	I avoid walking or exertion. I always use elevators, and drive whenever possible.
	Level 1:	I walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.
I participate regularly in recreation or work requiring modest physical activity such as golf, horseback riding, calisthenics, table tennis, bowling, weight lifting or yard work.	Level 2:	I perform 10 to 60 minutes per week of these activities.
	Level 3:	I perform over 1 hour per week of these activities.
I participate regularly in heavy physical exercise such as jogging or running, swimming, cycling, rowing, skipping rope, running in place, or engaging in vigorous aerobic exercise such as tennis, basket-ball or handball.	Level 4:	I run less than 1 mile per week or spend less than 30 minutes per week in comparable physical activity.
	Level 5:	I run 1 to 5 miles per week or spend 30 to 60 minutes per week in comparable physical activity.
	Level 6:	I run 5 to 10 miles per week, or spend 1 to 3 hours per week in comparable activity.
	Level 7:	I run over 10 miles per week or spend over 3 hours in comparable activity.

EF2 Do you have any physical problems or limitations which may affect your ability

to exercise?   Yes   No

EF3 Please mark how often you do each of the following:

Activity   Never   Sometimes   Usually
_____

Warm-up

Cool-down

Stretch

Exercise with the proper, activity-specific footwear

Perform strength training exercises on a regular basis

(at least twice per week)

APPENDIX B. STRESS QUESTIONAIRE

We are trying to understand the effect of work-related stress on law enforcement officers. You could help this research by answering the following questions.

For each question, please mark the answer that is most true for you. There are no "right" or "wrong" answers.

		Never	*Almost Never*	*Sometimes*	*Fairly Often*	*Often*
1	In the last month, how often have you been upset because of something that happened unexpectedly?	①	②	③	④	⑤
2	In the last month, how often have you felt that you were unable to control the important things in your life?	①	②	③	④	⑤
3	In the last month, how often have you felt nervous and "stressed'?	①	②	③	④	⑤
4	In the last month, how often have you dealt successfully with irritating life hassles?	①	②	③	④	⑤
5	In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?	①	②	③	④	⑤
6	In the last month, how often have you felt confident about your ability to handle your personal problems?	①	②	③	④	⑤
7	In the last month, how often have you felt that things were going your way?	①	②	③	④	⑤
8	In the last month, how often have you found you could not cope with all the things that you had to do?	①	②	③	④	⑤
9	In the last month, how often have you been able to control irritations in your life?	①	②	③	④	⑤
10	In the last month, how often have you felt that you were on top of things?	①	②	③	④	⑤
11	In the last month, how often have you been angered because of things that happened that were outside of your control?	①	②	③	④	⑤
12	In the last month, how often have you found yourself thinking about the things that you have to accomplish?	①	②	③	④	⑤
13	In the last month, how often have you been able to control the way you spend your time?	①	②	③	④	⑤
14	In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	①	②	③	④	⑤