Journal of Occupational and Environmental Medicine, Publish Ahead of Print
DOI: 10.1097/JOM.0000000000003316

Metabolic syndrome and associated components among police officers: A 7 and 12-year longitudinal analysis.

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Funding Sources for ALL Authors: This work was supported by the National Institute for Occupational Safety and Health (NIOSH), contract no. 200-2003-01580 and grant numbers 1R01OH 009640-01A1 and 1R01OH010807-01.

Conflict of Interest for ALL Authors: NONE DECLARED

Authors' contributions: *Conceptualization*: John M. Violanti; *Formal statistical analysis*: Desta Fekedulegn**;** *Writing – original draft*: John M. Violanti, Desta Fekedulegn, Anna Mnatsakanova, Tara A. Hartley, Ja K Gu, Service Samantha, & Penelope Allison**;** *Writing – Review & Editing*: All authors

Data Availability: The SAS data used to support the findings of this study have not been made available because of the sensitive nature of the health-related outcomes and the potential for participant re-identification.

AI Transparency and Accountability: No AI was utilized at any stage during research development & design, data collection, and manuscript preparation. STROBE guidelines were adhered to for reporting in this manuscript.

Ethical Considerations & Disclosure(s): The study was approved by the Internal Review Board of the State University of New York at Buffalo (IRB approval number/ID: See 45 C.F.R. part 46.101(c); 21 C.F.R. part 56). All participants signed written informed consent.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

Abstract

Objective: This study estimated risk of metabolic syndrome (MetSyn) and its components among police officers including differences by sex.

Methods: Police officers were examined at baseline and two follow-up examinations after 7 and 12 years. MetSyn was defined using the 2005 guidelines from AHA/NHLBI. Risk for incident MetSyn and its components at follow-up exams and risk ratios in males compared to females were estimated using modified Poisson regression.

Results: The 7 (n=276) - and 12- (n=191) year incidence of MetSyn was 20.4% and 22.2%, respectively. MetSyn components with lowest and highest incidence were reduced HDL cholesterol and abdominal obesity. The 7-year risk of developing glucose intolerance was two-fold higher in males compared to females.

Conclusion: Longitudinal analysis of incidence of MetSyn and its components is important for understanding future cardiovascular disease (CVD) morbidity and mortality.

Keywords: police, metabolic syndrome, cardiovascular disease, sex, longitudinal analysis

SMART learning outcomes - After completing this educational activity, the learner will be better able to:

- Discuss the long-term incidence of cardiovascular disease risk among police officers over seven and twelve-year periods.
- Upon completion of review, recognize the differences in metabolic risk between men and women police officers.
- Discuss possible reasons for the development of metabolic syndrome among police officers as compared to other occupations in the literature.

INTRODUCTION

According to the Bureau of Labor Statistics,(1) an estimated 832,500 law enforcement personnel will be employed in the United States by the year 2032. Persons entering police work are generally part of a healthy worker population, but their health appears to deteriorate physically and psychologically as years of police service increase.(2) Police officers have been found to have higher rates of cardiovascular disease (CVD) risk factors and CVD morbidity and mortality compared to other occupational groups and the general population.(3-5)

A recent U.S. police mortality study found that white male police officers had elevated mortality rates for diseases of the circulatory system, malignant neoplasms, cirrhosis of the liver, and mental disorders compared to the general population.(6) Lower mortality rates for all causes of death were observed among black officers and female officers compared to the general population.(6) Violanti et al. reported age-specific proportionate mortality ratios for arteriosclerotic heart disease to be highest among younger officers who served 10-19 years in police force, indicating that police officers most susceptible to heart disease were affected early in their careers.(2) A 22-year study of on duty police deaths found that cardiovascular related disease was a common cause of death (52.6 percent). Among circulatory causes, 81.8 percent were due to a fatal heart attack, 2.1 percent due to a cardiac arrest, and 14.1 percent due to probable circulatory causes like collapsing during training exercise or becoming unresponsive after chest pain.(7)

U.S. police officers were found to have elevated levels of age-adjusted CVD risk factors (e.g., blood pressure, alcohol use, smoking prevalence) compared with a general population sample.(8) In age, gender, and traditional risk factor-adjusted models, police officers exhibited increased thickness in the carotid artery compared to general population sample (Mean common

carotid artery (CCA): 0.67 mm in police, 0.64 mm in population sample; P = 0.03) which was not fully explained by elevated CVD risk factors.(8) A second study on the same populations compared flow mediated artery dilation (FMD) in police officers with that of general population sample from the same geographical region and free of clinical cardiovascular disease (CVD).(9) The authors found that police officers had significantly increased age-adjusted CVD risk factors (smoking prevalence and alcohol consumption) and exhibited decreased endothelial function compared with the civilian sample, which was not fully explained by traditional CVD risk factors.(9) A study on Iowa police found that public safety officers had a higher probability of developing coronary heart disease than the Framingham Heart Study population.(10)

Risk factors for CVD may cluster together into Metabolic syndrome (MetSyn). According to the 2001 National Cholesterol Education Program Adult Treatment Panel (ATP) III and incorporating recent modifications from the American Heart Association and National Heart, Lung, and Blood Institute, MetSyn is defined as abnormalities in any three or more of the following clinical measures: sex-specific waist circumference, triglycerides, sex-specific HDL cholesterol, blood pressure, and fasting glucose level.(11)

Police officers have been found to have an increased prevalence of MetSyn compared to other populations.(4, 12, 13) The age-adjusted prevalence of MetSyn is estimated at 20.6% for U.S. workers overall and 26.1% for protective service workers, including police officers.(14) An analysis of a police sample found MetSyn was present in 23.1% of 421 active law enforcement officers. This study also found a relationship between physical inactivity and the presence of MetSyn.(15) Another study of 98 police officers found an overall prevalence of MetSyn of 16.3 percent.(16) An expanded analysis from the same municipality (n=464) found that MetSyn was present in 26.7% of officers.(17)

There are limited studies examining sex differences in MetSyn. A comparison between 1988-1994 and 1999-2000 data obtained from the National Health and Nutrition Examination Survey (NHANES) found that the age-adjusted prevalence of MetSyn increased by 23.5% among women (p=0.021) and 2.2% among men (p=0.831).(18) Elevations in blood pressure, waist circumference, and triglyceride levels have been found to account for increases in MetSyn prevalence for women.(19)

The preponderance of the evidence suggests that individuals working in law enforcement have an increased risk of cardiovascular morbidity and mortality. The objectives of this longitudinal study were to estimate 7-and 12-year risks of MetSyn and its individual components in U.S. police officers and to examine sex differences in incidence. There were no prior prospective studies among U.S. police officers that provided data on risk estimates for MetSyn and its components. Additionally, data on MetSyn among female officers are limited.

METHODS

Study Design and Participants

The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Study was a longitudinal study initiated to investigate associations between stressors unique to the law enforcement profession and psychological and physiological health outcomes. The study participants were police officers who worked in the Buffalo, New York Police Department. Three examinations over a period of 12 years were completed (Figure 1): a baseline examination with 464 officers (2004-2009), the 1st follow-up examination with 300 officers (2011-2015), and the 2nd follow-up examination with 240 officers (2015-2019). Data for all exams were collected at the Center for Health Research, School of Public Health and Health Professions, University at

Buffalo, State University of New York. A written informed consent was collected from each participant at each of the three examinations. This study was reviewed and approved by the Internal Review Board (IRB) of the State University of New York at Buffalo (IRB approval number/ID: See 45 C.F.R. part 46.101(c); 21 C.F.R. part 56).

For the baseline examination (Exam 1), a total of 710 police officers who worked with the Buffalo, New York Police Department were invited to participate; 464 (65.4%) active-duty and retired police officers agreed to participate and were examined during 2004 to 2009. No specific inclusion criteria were indicated for the study, only that participants be sworn police officers and willing to participate. The first follow-up examination (Exam 2) was conducted nearly 7 years later when a total of 300 officers were examined between 2011 and 2015; of the 300, 276 were part of the original cohort evaluated at the baseline examination while the remaining 24 were new recruits added at Exam 2 (Figure 1). The second follow-up examination (Exam 3) was conducted approximately 12 years from baseline when a total of 240 officers were examined; of the 240, 191 officers were part of the original cohort evaluated at the baseline examination. At each examination a comprehensive evaluation of the participants was performed to collect data on demographic and lifestyle factors, occupational exposures, psychosocial factors, and physical health outcomes. Female officers who were pregnant at the time of examination were excluded. Further details on recruitment, data collection, and variables assessed are described elsewhere.(20) This article was prepared following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines (see STROBE checklist as Supplementary Data 1, http://links.lww.com/JOM/B818).

Demographic and Lifestyle Factors

Demographic characteristics (age, gender, race/ethnicity, education, marital status, years employed as a police officer, and rank) and lifestyle behaviors (smoking status, alcohol intake, and hours of physical activity) were obtained using self-administered questionnaires. Alcohol consumption was ascertained using data from the Food Frequency Questionnaire (FFQ) related to drinking patterns. Physical activity level was assessed using the Seven-Day Physical Activity Recall questionnaire, an interviewer administered questionnaire developed in the Stanford Five-City Project.(21) Medication use was ascertained through self-report and by inventory of current medications that the participants brought to the clinic (exam center) on their date of interview.

Blood Samples, Blood Pressure, and Waist Circumference

A fasting blood sample (20 ml) was obtained from all participants by a trained phlebotomist. Blood parameters [HDL cholesterol (mg/dL), triglycerides (mg/dL), and glucose (mg/dL)] were measured by standard laboratory techniques. After the participants had rested in the supine position for five minutes, three blood pressure (BP) measurements were taken two minutes apart. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were derived as the mean of the three respective measurements. Waist circumference was measured as abdominal girth at the highest point of the iliac crest and the lowest point of the costal margin in the mid-axillary line. Three measurements of waist circumferences were taken, and the average value was used as the participant's waist circumference.

Metabolic Syndrome (MetSyn) and its Components

Assessment of MetSyn and its components were based on criteria by the National Cholesterol Education Program Adult Treatment Panel III guidelines with recent modifications from the American Heart Association and the National Heart, Lung, and Blood Institute.(11)

Further description of the assessment of MetSyn for the BCOPS study was provided by Hartley et al. (2011).(22) The five individual MetSyn components included: 1) abdominal obesity (gender-specific waist circumference ≥ 102 cm in males, ≥ 88 cm in females); 2) elevated triglycerides (fasting triglycerides ≥ 150 mg/dL, or reported treatment with nicotinic acid or fibrates); 3) reduced HDL-C (gender-specific fasting HDL-C < 40 mg/dL in men, < 50 mg/dL in women, or reported treatment with nicotinic acid or fibrates); 4) glucose intolerance (fasting serum glucose ≥ 100 mg/dL, or reported treatment for diabetes); and 5) hypertension (systolic blood pressure ≥ 130 mmHg, diastolic blood pressure ≥ 85 mmHg, or reported physician-diagnosed hypertension and antihypertensive treatment). The five components each coded 0/1 (0 = for absence of the component, 1= for presence of the component) were summed to get the total count of MetSyn components (range 0 – 5). MetSyn was considered present if an individual had at least three components (sum of components ≥ 3).

Data analysis

We conducted two sets of analysis to estimate incidence over the 7- and 12-year follow-up periods. To estimate incidence over the 7-year follow-up period, a participant must have been examined at both the baseline and the 1st follow-up examination (n = 276) and participants were excluded if they met the following two conditions: (a) prevalent cases (those with MetSyn or any component at baseline) and (b) those with missing status for MetSyn or its components at either examination (see Table 1 for inclusion/exclusion criteria and analytic sample sizeI). Similar inclusion and exclusion criteria were used to estimate incidence over the 12-year follow-up period (Table 1). Descriptive statistics were used to tabulate baseline characteristics of the participants at risk of MetSyn and sex differences in baseline covariates were tested using Chi-

Square tests of independence or Fisher's exact test for categorical covariates and analysis of variance (ANOVA) for continuous covariates.

The risk and risk ratio (RR) of MetSyn and its components by sex were calculated using the Poisson regression with robust variance estimation, often called the modified Poisson regression.(23) A RR was considered statistically significant if the 95% CI did not include 1. All statistical analyses were performed using the SAS software version 9.4.(24) Significance level was set at 5%. Comparison of incidence across sex was adjusted for covariates (age, race/ethnicity, education, marital status, police rank, smoking status, alcohol consumption, and physical activity) that may be related to the dependent variable (MetSyn and its components) or the independent variable (sex).

RESULTS

Demographic and lifestyle characteristics

Baseline characteristics of participants at risk for metabolic syndrome during the 7-year follow-up (n=216): The baseline demographic and lifestyle characteristics of the sample, overall and by sex, are presented in Table 2. The study sample had a mean age of 40.6 years (SD = 7.2), was predominantly male (67%), Caucasian (79%), married (71%), and 92% had at least some college education. The majority held the rank of patrol officer (74%) and were former or never smokers (85%). Overall, there were no significant differences between men and women officers with respect to education, smoking status, rank, age, years of service, and physical activity. However, there were significant sex differences with respect to race, marital status, and alcohol consumption. The proportion of black and Hispanic officers is significantly higher among women (29.0%) than among men (17.0%) (p=0.003) (Table 2). The proportion of

single/divorced officers was significantly higher among women (47.0%) than among men (20.0%) ($p<0.001$) (Table 2). Alcohol consumption was significantly higher among men than women (5.9 ± 8.5 vs. 3.1 ± 4.2, $p=0.011$). BMI, waist circumference, triglyceride, and fasting glucose were significantly higher in men than women ($p<0.001$) while HDL cholesterol was higher in women than in men ($p<0.001$).

Baseline characteristics of participants at risk for metabolic syndrome during the 12-year follow-up (n=153): In this sample (n=153) that was followed over the 12-year period, the distribution of sex, race/ethnicity, rank, and educational, marital, smoking status and mean age are nearly identical to the sample followed over the 7-year period (n=216) (Table 2). Similar to those followed over 7-years, this group also has no significant sex differences with respect to education, smoking status, rank, age, years of service, and physical activity. There were significant sex differences with respect to marital status and alcohol consumption. The proportion of single/divorced officers was significantly higher among women (46.0%) than among men (17.0%) ($p<0.001$) (Table 2). Alcohol consumption was significantly higher among men than women. BMI, waist circumference, triglyceride, and fasting glucose were significantly higher in men than women ($p<0.001$) while HDL cholesterol was higher in women than in men ($p<0.001$). These results were consistent as in those followed over 7-years.

Incidence estimates

7-year incidence

The 7-year incidence of MetSyn was 20.4% (95% CI: 15.7, 26.5) and the incidence of the components ranged from a low of 12.1% for reduced HDL cholesterol to a high of 28.6% for abdominal obesity (Table 3). In males, the 7-year incidence of MetSyn was 22.2% (95% CI:

16.4, 30.2) and the incidence of the components ranged from a low of 12.1% for reduced HDL cholesterol to a high of 25.6% for abdominal obesity (Table 4). In females, the 7-year incidence of MetSyn was 16.7% (95% CI: 9.9, 27.9) and the incidence of the components ranged from a low of 6.8% for hypertension and elevated triglycerides to a high of 34.4% for abdominal obesity (Table 4). The 7-year incidence represents risk or probability of developing MetSyn or its components as participants age by 7-years.

12-year incidence

The 12-year incidence of MetSyn was 22.2% (95% CI: 16.5, 29.9) and the incidence of the components ranged from a low of 13.8% for reduced HDL cholesterol to a high of 37.5% for abdominal obesity (Table 3), consistent with the pattern seen during the 7-year follow-up. In males, the 12-year incidence of MetSyn was 22.9% (95% CI: 16.1, 32.5) and the incidence of the components ranged from a low of 11.9% for reduced HDL cholesterol to a high of 37.9% for abdominal obesity (Table 4). In females, the 12-year incidence of MetSyn was 20.8% (95% CI: 12.0, 36.2) and the incidence of the components ranged from a low of 13.6% for glucose intolerance to a high of 36.6% for abdominal obesity (Table 4). The 12-year incidence represents risk or probability of developing MetSyn or its components as participants age by 12-years.

Sex differences in incidence

The 7-year unadjusted risk of MetSyn and its components was higher in males than females except for abdominal obesity where the incidence in males was 26% lower compared to females (RR = 0.74, 95% CI: 0.47, 1.17) but it was not statistically significant (Table 4). The overall incidence of MetSyn was 33% higher in males than females (RR = 1.33, 95% CI: 0.73, 2.43), but it was not statistically significant. The sex difference in risk of elevated triglyceride was marginally significant where the incidence in males was 2.5 times as high as in females (RR

= 2.49, 95% CI: 0.98, 6.30; p-value = 0.0539). Incidence of glucose intolerance was 69% higher in males than females but did not reach statistical significance (RR = 1.69, 95% CI: 0.90, 3.18; p-value = 0.1050). After adjustment for demographic and lifestyle factors, sex difference in glucose intolerance attained statistical significance where the incidence in males was two-fold higher (RR = 2.16, 95% CI: 1.11, 4.20, p=0.0234). The risk of hypertension was three-fold higher in males relative to females (RR = 3.21, 95% CI: 1.18, 8.76; p-value = 0.0226). On the other hand, covariate adjustment attenuated the sex difference in incidence of hypertension (RR = 2.08, 95% CI: 0.70, 6.18) rendering it statistically non-significant.

The 12-year unadjusted risk of MetSyn and its components was higher in males than females except for reduced HDL cholesterol where the incidence in males was 34% lower compared to females (RR = 0.66, 95% CI: 0.27, 1.161) but it was not statistically significant (Table 4). Although it did not attain statistical significance, male officers had a notably higher 12-year incidence of glucose intolerance by 86% (RR = 1.86, 95% CI: 0.83, 4.17), hypertension by 45% (RR = 1.45, 95% CI: 0.73, 2.90), and elevated triglyceride by 54% (RR = 1.54, 95% CI: 0.71, 3.34) compared to their female counterparts. Covariate adjustment did not impact statistical significance of sex differences in 12-year incidence but there were notable changes in effect size before and after multivariate adjustment; the incidence of MetSyn in males was only 10% higher before adjustment compared to 53% higher following adjustment and the incidence of glucose intolerance was 86% higher in males before adjustment compared to 159% higher following adjustment.

Generally, the sex differences in incidence during the two-follow-up periods (7- vs. 12-year) are consistent except for abdominal obesity and reduced HDL cholesterol. Over 7-year follow-up incidence of abdominal obesity was 26% lower in males than females, but the

difference was not statistically significant (Table 4, unadjusted model) while during the 12-year follow up the incidence of abdominal obesity was identical in males and females. On the other hand, during the 7-year follow-up the incidence of reduced HDL cholesterol was nearly identical in males and females while during the 12-year follow-up the incidence of reduced HDL in males was 34% lower compared to females, yet the difference did not attain statistical significance.

DISCUSSION

General Findings on Incident MetSyn

Despite sufficient scientific evidence of the prevalence of CVD risk factors in the occupation of policing, to date there are no longitudinal studies among U.S. police officers that examined the risk of MetSyn and its individual components and potential sex differences in incidence. Understanding the magnitude of the risk of MetSyn and its components in police officers is an important step for mitigating future CVD morbidity and mortality. This longitudinal study addressed the research gap by estimating the 7-and 12-year risk of MetSyn and its components. The 7-year risk for developing MetSyn among officers without any prevalent MetSyn component was 20.4% and the 12-year risk was 22.2%. This means 20% of the sample, who at baseline did not have any MetSyn components, developed at least three of five the components in the span of seven years. Similarly, 22% of the sample who were free of any MetSyn component at baseline developed three or more components over a 12-year period. During both follow-up periods, individual MetSyn components with lowest and highest incidence were reduced HDL cholesterol and abdominal obesity, respectively.

Previous studies of incident MetSyn are limited. In their study of male and Italian police officers, Garbarino and Magnavita (2015) reported the five-year MetSyn incidence was 17.5%

compared to 22.2% for male officers at seven years in the current study.(25) There were also differences in the incidence of each component compared to the current study; some of which may be explained by the different MetSyn definitions applied. Incident MetSyn cases using ICD-9 and ICD-10 diagnostic codes were 7.5 per 100,000 person-years for active duty U.S. Armed Forces personnel between 2002-2017 with the incidence being twice as high for female vs. male service members (13.9 vs. 6.4 per 100,000 person-years).(26)

Potential Reasons for MetSyn Development in Police Officers

The development of MetSyn among police may be due to many factors, including stress. Chronic stress leads to hyperactivity of the hypothalamic pituitary adrenal (HPA) axis, thereby elevating cortisol levels and leading to the development of visceral adiposity, hypertension, and dyslipidemia, components of the MetSyn.(25, 27, 28) Police work is a noted high stress occupation.(29-34) Sources of chronic stress in police work include shift work, long work hours, organizational stressors, and repeated exposure to traumatic events and threats to physical and psychological health.(35-38) In addition, acute, sudden and intense exposure to traumatic events and threats to self lead to unpredictable bursts of physical response, which may place a high demand on the cardiovascular system including elevations in heart rate and blood pressure.(39) Trauma may also lead to development of post-traumatic stress disorder (PTSD), and PTSD has been associated with increased risk of hypertension, obesity, dyslipidemia, and CVD.(40)

Studies have examined the association between stress and CVD in police officers. Garbarino and Magnavita reported increased adjusted risks of developing MetSyn and hypertriglyceridemia among police officers reporting high levels of stress.(25) A study by Hartley et al.(22) found that the adjusted number of MetSyn components increased significantly in women police officers across tertiles of organizational pressure and lack of support; while no

associations were found in male officers. Abdominal obesity and reduced HDL-C were the components consistently associated with police stress in women. (22)

Greater perceived stress has been associated with increased prevalence of CVD and its risk factors.(4, 10) It was estimated that 41% of police officers have a stress-related physical health problem, such as hypertension.(41) Police officers under stress have a more adverse CVD risk factor profile and higher CVD mortality rates compared to other occupations and the general population.(7, 10) Police officers in the highest quartile of stress had significantly higher mean levels of triglycerides than their colleagues in the lowest quartile.(25) A study of Polish police officers reported positive correlation between higher perceived stress on the job and the prevalence of MetSyn.(42)

Police-related lifestyle factors may also influence MetSyn. Although officers come into policing as physically fit, the sedentary nature of police coupled with stress contributes to the development of MetSyn.(41) The majority of police work time involves sitting in patrol cars, writing reports, or interviewing persons.(43) Increased levels of obesity and the higher waist size, component of MetSyn, are likely related to this lack of physical activity and increased sitting time.(44) Anderson and colleagues (2016) found a two-fold increase in adjusted odds for MetSyn among officers reporting low vs. high levels of physical activity.(45) Lack of regular physical activity was found to be one of the occupational risk factors contributing to the higher prevalence of elevated blood pressure, MetSyn, and CVD among emergency responders including police officers.(46)

Shift work also may increase the risk for components of MetSyn. Irregular work hours, specifically those at night and early morning, were reported to be associated with adverse levels of waist circumference and triglycerides in men and triglycerides in women who participated in a

British birth cohort study.(47) In a small pilot study of police officers, those working the night shift combined with short sleep duration had significantly more MetSyn components than those working day shift with short sleep duration.(16)

Dietary patterns have been associated with MetSyn. Lutsey et al., 2008 found in a large cardiovascular disease study of middle-aged men and women that a Western dietary pattern, and consumption of meat, fried foods, and diet soda were negatively associated with incident MetSyn.(48) While no studies of dietary patterns and metabolic syndrome in police officers were identified, dietary patterns in officers have been associated with other MetSyn risk factors, including shift work, inactivity, and long work hours. Bonnell and colleagues found that while overall energy intake was similar between day and night shift officers, night shift workers consumed higher energy dense foods.(49) Gibson et al., 2018, found that male officers working 49 hours or more per week compared to less than 40 hours per week and males reporting high versus low job strain had significantly poorer diet quality than men officers. In the same study, low levels of weekly physical activity compared to high levels were significantly associated with poorer diet quality in male and female officers.(50)

Sex Differences in Incident MetSyn and Components

In the present study, the 7-year risk of glucose intolerance was two-fold higher in males compared to females after covariate adjustment while the risk of hypertension was 3-fold higher in males than females, but the effect was attenuated after covariate adjustment. Sex differences in overall Metsyn, abdominal obesity, elevated triglyceride, and reduced HDL cholesterol during both follow-up periods were not statistically significant. Although these findings did not reach statistical significance, they point toward potential differences in MetSyn risk by sex. Future studies with more female police officers are desirable.

Study Strengths and Limitations

The use of a specific police department as our study population may limit generalizability of our findings to other departments that have somewhat different characteristics. Additional limitations include the fact that the participants at baseline were volunteers which lends itself to a potential self-selection bias and that there was a significant attrition during both the 7-year follow-up (40.5%=188/464) and the 12-year follow-up (58.8%=273/464) period. Even with appropriate recognition of this limitation, similar CVD health problems are seen among police in other cities, states, and countries. Police work is a specific occupation and officers are exposed to unique stressors likely not seen in other work. This may affect comparability to the general population. However, findings in the present study may be relevant to other occupations characterized as first responders. A potential confounder in this type of analysis is the healthy worker effect.(51) Those who graduate from the police academy are necessarily young, healthy individuals who must meet the rigorous physical, medical, and emotional standards required of police work. Less healthy individuals who fail these standards are excluded. Therefore, the healthy worker effect may lower the relative occupational mortality risk of law enforcement personnel compared with the general population, particularly among younger officers. The present study has several strengths. Due to the longitudinal design, we were able to calculate risk estimates, change or progression in subclinical markers, regarding indicators of MetSyn that are not available in cross-sectional or retrospective data.

CONCLUSIONS

Given the high prevalence of CVD risk factors among police officers, longitudinal analysis of incidence of MetSyn and its individual components is important for understanding

future CVD morbidity and mortality among police officers. To a degree, the present study points to the development of health problems in police work particularly in CVD. Additionally, this study has contributed new information on women in policing and how their health is affected by police work. In response to increased research on police health, many police organizations have begun to place an emphasis on physical fitness, healthy lifestyle behaviors, and prevention efforts.(52) The recent finding that life expectancy of white male police officers was, on average, significantly lower than that of the U.S. population underscores the need for emphasis on good health throughout the police career.(53) Employer wellness plans for developing meaningful physical activity levels, proper nutrition, sleep quality, weight control, and stress management are important in this occupation that requires physically and mentally fit individuals to perform the important societal task of law enforcement and service to the public.(54)

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Figure legends.

Figure 1. The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Study Design and Sample Size.

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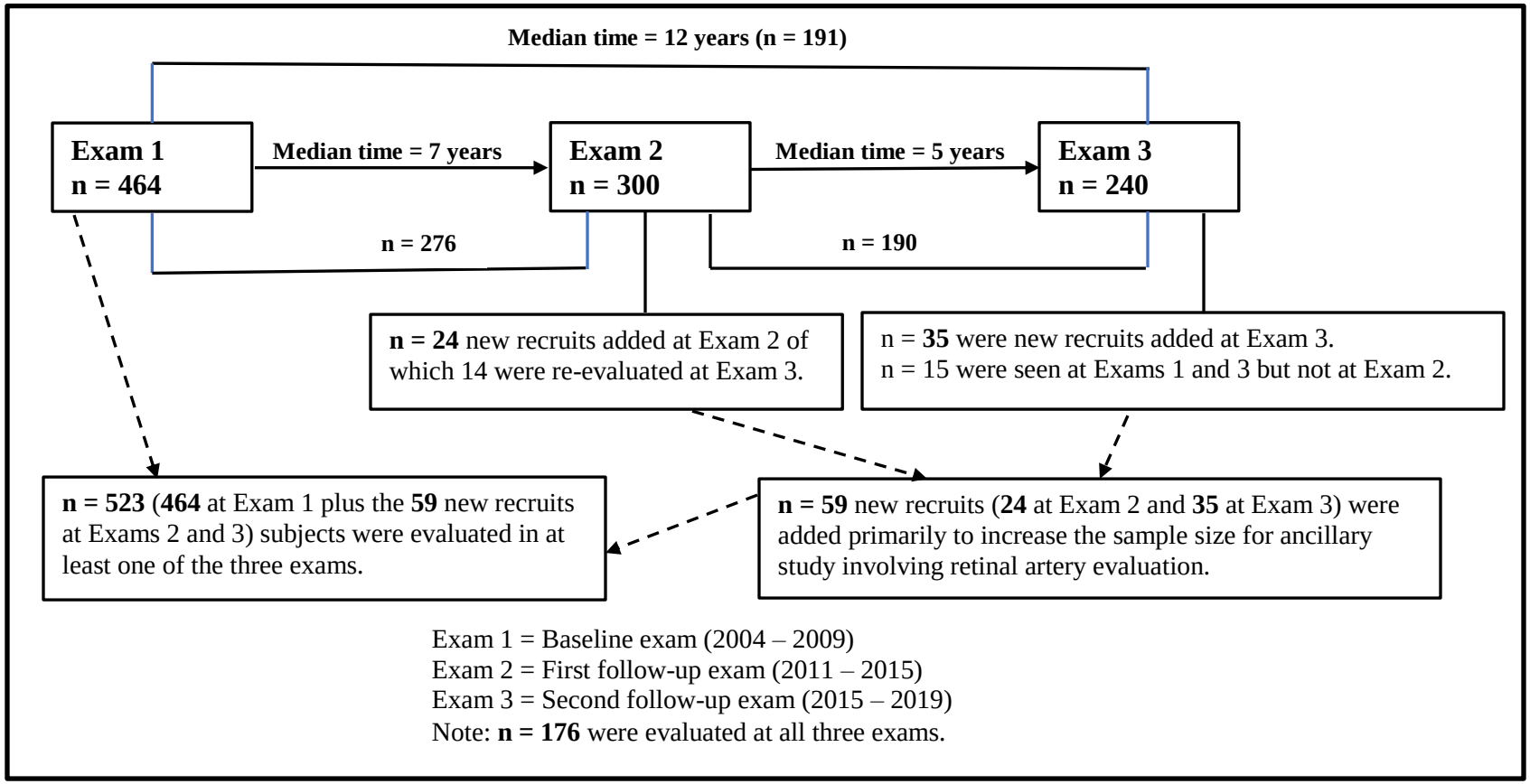


Table 1. Prevalent cases and analytic sample size for estimating the 7- and 12-year incidence of metabolic syndrome and its components (exclusion and inclusion criteria).

	7-year follow-up (n = **276** seen at both Ex1 and Ex2)			12-year follow-up (n = **191** seen at both Ex1 and Ex3)		
Outcome (health condition)	Prev. cases (%)	No. with missing data on outcome	At risk	Prev. cases (%)	Missing status on outcome	At risk
Metabolic syndrome	57 (20.7)	3	216	34 (17.8)	4	153
Abdominal obesity	84 (30.4)	3	189	51 (26.7)	4	136
Elevated triglyceride	73 (26.4)	1	202	48 (25.1)	0	143
Reduced HDL cholesterol	101 (36.6)	1	174	68 (35.6)	0	123
Glucose intolerance	50 (18.1)	1	225	29 (15.2)	0	162
Hypertension	92 (33.3)	1	183	51 (26.7)	0	140

Prev. cases (%)= prevalent cases or number of subjects who already had the health condition at the start of the study (percentage of prevalent cases); *No. with* m*issing data on outcome* = number of subjects with missing outcome status at either examination; *At risk* = number of subjects who do not have the health condition at baseline and hence are at risk of developing the health condition at follow-up (**analytic sample size**).

Table 2. Baseline characteristics of study participants by sex among those at risk for metabolic syndrome.

	7-year follow-up (Ex1 to Ex2) (n=216)							12-year follow-up (Ex1 to Ex3) (n=153)						
	All (n=216)		Men (n = 144)		Women (n = 72)			All (n=153)		Men (n = 105)		Women (n = 48)		
Characteristics	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[1]**	**n**	**%**	**n**	**%**	**n**	**%**	**p-value[1]**
Race							**0.003**							0.256
White	171	79.0	120	83.0	51	71.0		123	80.0	87	83.0	36	75.0	
Black/Hispanic	45	21.0	24	17.0	21	29.0		30	20.0	18	17.0	12	25.0	
Education							0.358							0.923
≤High school/GED	17	8.0	13	9.0	4	6.0		10	93.0	7	7.0	3	6.0	
College (<4 or 4+ yrs.)	197	92.0	129	91.0	68	94.0		143	7.0	98	93.0	45	94.0	
Marital status							**<0.001**							**<0.001**
Married	153	71.0	115	80.0	38	53.0		113	74.0	87	83.0	26	54.0	
Single/divorced	62	29.0	28	20.0	34	47.0		40	26.0	18	17.0	22	46.0	
Smoking status							0.067							0.057
Current	32	15.0	17	12.0	15	21.0		23	15.0	12	11.0	11	23.0	
Former/never	181	85.0	126	88.0	55	79.0		129	85.0	93	89.0	36	77.0	
Rank							0.513							0.346
Patrol officer	159	74.0	104	72.0	55	76.0		117	76.0	78	74.0	39	81.0	
Other[2]	57	26.0	40	28.0	17	24.0		36	24.0	27	26.0	9	19.0	
Age (in years)	216	40.6 ± 7.2	144	40.3 ± 7.7	72	41.1 ± 6.2	0.460	153	39.9 ± 7.3	105	39.7 ± 7.8	48	40.2 ± 6.1	0.700
Years of service	214	13.8 ± 7.6	142	14.0 ± 7.9	72	13.4 ± 6.7	0.606	152	12.8 ± 7.5	104	13.1 ± 8.0	48	12.2 ± 6.4	0.507
Hours of physical activity/week[3]	216	21.7 ± 18.1	144	21.0 ± 18.2	72	23.1 ± 17.7	0.413	153	20.9 ± 18.0	105	21.0 ± 18.7	48	20.7 ± 16.5	0.930
No. of alcohol drinks/week	212	5.0 ± 7.5	142	5.9 ± 8.5	70	3.1 ± 4.2	**0.011**	150	4.8 ± 7.2	104	5.8 ± 8.2	46	2.4 ± 3.3	**0.007**
Systolic BP (mm Hg)	216	118.3 ± 10.2	144	119.3 ± 9.1	72	116.4 ± 12.1	0.054	153	117.0 ± 10.3	105	118.7± 9.1	48	113.4 ± 11.8	**<0.001**
Diastolic BP (mm Hg)	216	75.6 ± 8.4	144	76.4 ± 8.5	72	74.1 ± 7.9	0.057	153	75.0 ± 8.2	105	75.7 ± 8.3	48	73.5 ± 7.8	0.125
Body mass index (kg/m^2)	216	28.0 ± 4.1	144	29.3 ± 3.8	72	25.4 ± 3.6	**<0.001**	153	27.8 ± 3.7	105	29.0 ± 3.3	48	25.2 ± 3.1	**<0.001**
Waist circumference (cm)	216	90.1 ± 13.0	144	96.0 ± 10.5	72	78.5 ± 9.0	**<0.001**	153	90.0 ± 12.4	105	95.4 ± 9.7	48	78.2 ± 9.3	**<0.001**
HDL cholesterol (mg/dL)	213	50.6 ± 14.9	144	45.9± 11.5	69	60.5 ± 16.5	**<0.001**	151	50.3 ± 14.2	105	46.1 ± 11.1	46	59.8 ± 15.8	**<0.001**
Triglyceride (mg/dL)	213	94.8 ± 56.1	144	106.0± 58.3	69	71.5 ± 43.3	**<0.001**	151	94.2 ± 55.8	105	105.5 ± 60.1	46	68.3 ± 32.6	**<0.001**
Glucose (mg/dL)	214	89.5± 8.3	144	91.1± 7.9	70	86.3± 8.3	**<0.001**	151	89.0 ± 9.0	105	90.7 ± 8.8	46	85.3 ± 8.4	**<0.001**
Diagnoses of CAD[4]							0.5535							1.0000
Yes	2	0.93	2	0.93	0	0.0		2	1.31	2	1.9	0	0.0	
No	214	99.1	142	98.6	72	100.0		151	98.7	103	98.1	48	100.0	

[1]P-values are from χ^2 tests of independence or Fisher's exact test for categorical variables and from ANOVA testing differences in means between the sexes for continuous variables. Results for the continuous variables are means ± SD. [2]Other includes sergeant, lieutenant, captain, and detective. [3]Physical activity hours include occupational, household, and leisure time activities. [4]Self-reported history of coronary artery disease (CAD). Note that some variables (covariates) have missing data for few subjects.

Table 3. Incidence of metabolic syndrome and its components among police officers (overall sample).

	7-year follow-up			12-year follow-up		
Outcome	**N at risk**	**n cases**	**Incidence (95% CI)**	**N at risk**	**n cases**	**Incidence (95% CI)**
Metabolic syndrome	216	44	20.4% (15.7, 26.5)	153	34	22.2% (16.5, 29.9)
Abdominal obesity	189	54	28.6% (22.8, 35.8)	136	51	37.5% (30.2, 46.6)
Elevated triglyceride	202	27	13.4% (9.4, 19.0)	143	29	20.3% (14.7, 28.1)
Reduced HDL cholesterol	174	21	12.1% (8.1, 18.0)	123	17	13.8% (8.9, 21.5)
Glucose intolerance	225	49	21.8% (17.0, 27.9)	162	36	22.2% (16.7, 29.6)
Hypertension	183	31	16.9% (12.3, 23.4)	140	37	26.4% (20.1, 34.8)

N at risk = number of subjects at risk for the outcome (health condition) at baseline (Ex1); **n** cases = number of new cases of the health condition at the end of follow-up; Incidence = risk (probability) of developing the health condition during the follow-up period.

Table 4. Sex stratified incidence of metabolic syndrome and its components and risk ratio (RR) comparing incidence in males versus females.

	7-year follow-up					12-year follow-up				
Outcome (health condition)	**N** at risk	**n** cases	Incidence (95% CI)	RR^1 (95% CI)	RR^2 (95% CI)	**N** at risk	**n** cases	Incidence (95% CI)	RR^1 (95% CI)	RR^2 (95% CI)
Metabolic syndrome										
Males	144	32	22.2% (16.4, 30.2)	1.33 (0.73, 2.43)	1.55 (0.76, 3.16)	105	24	22.9% (16.1, 32.5)	1.10 (0.57, 2.11)	1.53 (0.70, 3.35)
Females	72	12	16.7% (9.9, 27.9)	Ref.	Ref.	48	10	20.8% (12.0, 36.2)	Ref.	Ref.
Abdominal obesity										
Males	125	32	25.6% (19.0, 34.5)	0.74 (0.47, 1.17)	0.87 (0.50, 1.50)	95	36	37.9% (29.3, 49.0)	1.04 (0.64, 1.67)	1.08 (0.61, 1.89)
Females	64	22	34.4% (24.5, 48.2)	Ref.	Ref.	41	15	36.6% (24.5, 54.7)	Ref.	Ref.
Elevated triglyceride										
Males	129	22	17.1% (11.7, 25.0)	**2.49 (0.98, 6.30)**	2.57 (0.96, 6.90)	96	22	22.9% (15.9, 33.1)	1.54 (0.71, 3.34)	1.42 (0.55, 3.67)
Females	73	5	6.9% (2.9, 16.0)	Ref.	Ref.	47	7	14.9% (7.5, 29.5)	Ref.	Ref.
Reduced HDL cholesterol										
Males	115	14	12.1% (7.5, 19.9)	1.03 (0.44, 2.40)	1.35 (0.55, 3.34)	84	10	11.9% (6.7, 21.3)	0.66 (0.27, 1.61)	0.84 (0.34, 2.06)
Females	59	7	11.9% (5.9, 23.8)	Ref.	Ref.	39	7	18.0% (9.1, 35.1)	Ref.	Ref.
Glucose intolerance										
Males	157	39	24.8% (18.9, 32.6)	**1.69 (0.90, 3.18)**	**2.16 (1.11, 4.20)**	118	30	25.4% (18.9, 34.6)	1.86 (0.83, 4.17)	**2.59 (0.92, 7.25)**
Females	68	10	14.7% (8.3, 26.1)	Ref.	Ref.	44	6	13.6% (6.5, 28.7)	Ref.	Ref.
Hypertension										
Males	124	27	22.8% (15.6, 30.4)	**3.21 (1.18, 8.76)**	2.08 (0.70, 6.18)	100	29	29.0% (21.3, 39.4)	1.45 (0.73, 2.90)	1.25 (0.63, 2.46)
Females	59	4	6.8% (2.6, 17.5)	Ref.	Ref.	40	8	20.0% (10.8, 37.2)	Ref.	Ref.

N at risk = number of subjects at risk for health condition at baseline (Ex1); **n** cases = number of new cases of the health condition at the end of follow-up; Incidence = risk (probability) of developing the health condition during the follow-up period; RR^1 = risk ratio comparing incidence in males versus females (unadjusted); RR^2 = risk ratio comparing incidence in males versus females (adjusted for age, race/ethnicity, education, marital status, police rank, smoking status, alcohol consumption, and physical activity).

STROBE Statement—checklist of items that should be included in reports of observational studies

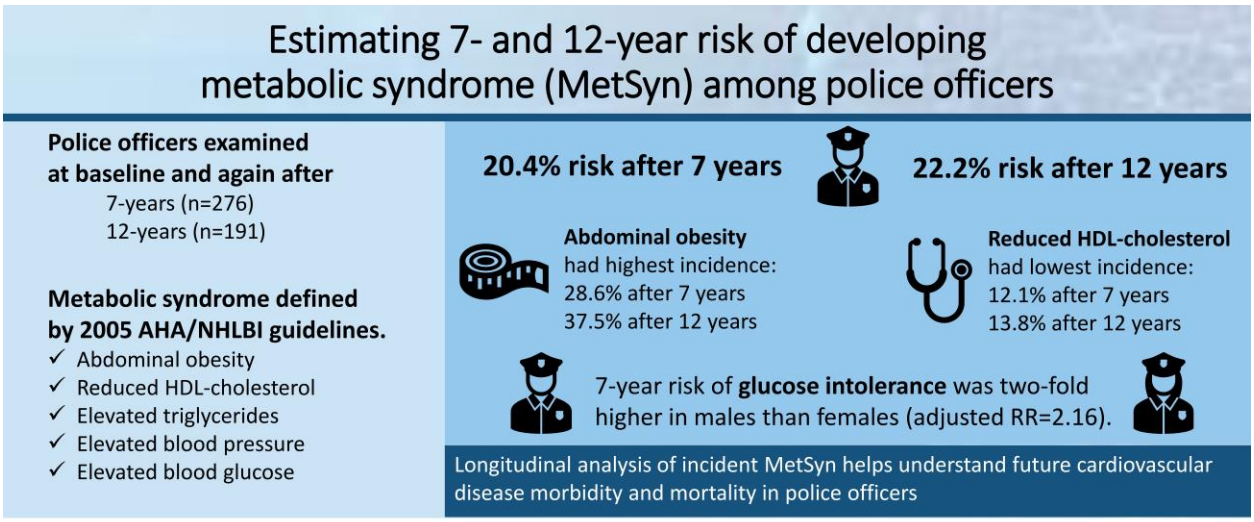
	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5,6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	16,17
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7,8
		(*b*) Describe any methods used to examine subgroups and interactions	7,8
		(*c*) Explain how missing data were addressed	7,8
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	

Continued on next page

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5,6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	-
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	5,6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	7
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16,17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.



Metabolic syndrome and associated components among police officers: A 7 and 12-year longitudinal analysis

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