**Work-related stress as a cardiovascular risk factor in police officers: a systematic review of evidence**

# Work-related stress as a cardiovascular risk factor in police officers. A systematic review of evidence.

Magnavita N [1], Capitanelli I [1*], Ciprani F [2], Garbarino S [2,3], Pira E [4].

(1) Institute of Public Health, Università Cattolica del Sacro Cuore, Rome, Italy
(2) Central Health Service, State Police, Ministry of Interior, Rome, Italy
(3) DINOGMI, University of Genoa, Genoa, Italy
(4) Occupational Health, University of Turin, Turin, Italy

*Corresponding author: Ilaria Capitanelli e.mail:ilaria.capitanelli@yahoo.it +39/3386108882

**Abstract**

**Purpose**
Several studies suggest that work-related stress in police officers may be associated with an increased risk of cardiovascular diseases. A systematic review of studies is, however, still lacking.

**Method**
According to PRISMA statement, a systematic search of PubMed, ISI Web of Science, Cinahl and PsychInfo electronic databases was undertaken. Studies published in English between 1/1/2000 and 31/12/2016 were included. A studies quality assessment was performed using the Newcastle Ottawa scale (NOS).

**Results**
The preliminary search retrieved 752 records. After selection, 16 studies (total population 17,698) were retrieved.
The average quality of studies was low. Exposure to stress in cross-sectional studies was inconstantly associated with hypertension, obesity, dyslipidaemia, and impaired glucose metabolism. In addition, there was a prevalence of positive studies showing an association between stress and cardiovascular disease morbidity. Studies of higher quality, such as longitudinal studies on large sample size, were more supportive of a significant positive association between stress and cardiovascular risk factors. Results were, however, often conflicting and inconsistent with regard to definitions and measurement of stress, features of individual study design, study conduct, and conclusions drawn.

**Conclusions**
A sound precautionary principle would be to adopt worksite health promotion programs designed to implement stress management strategies in this category of workers.

**Keywords**
Police officers · Cardiovascular disease · Cardiovascular risk factors · Stress · Public safety

## Introduction

Stress is a ubiquitously present but invisible enemy of the cardiovascular (CV) system. Although the pathophysiological mechanism of action is not completely understood, living through prolonged stressful situations results in brain hyperactivity that increases circulating levels of neuro-hormonal mediators. These molecules affect metabolic processes and inflammatory response, leading to vascular atherosclerosis and cardiovascular diseases (CVD) (Bellisarii et al. 2001; Chandola et al. 2008; Dragano et al. 2017; Kanda and Takahashi 2004; Siegrist 2001; Ueyama et al. 2003; Van Tassell et al. 2015).

Sources of stress can be multifactorial as stress may be the result of traumatic life events or work demands and pressure that are not aligned with individual knowledge and skills and, therefore, challenge personal ability to cope.

Studying stress in the police is particularly important. Police work, in fact, is known to be a physically and psychologically demanding job (Violanti et al. 2006). Police officers may be exposed to highly emotional events as for example when they are involved in physical clashes, witness a fellow officer being badly injured or killed, help battered children or women, or are themselves victims of violence. These kinds of experiences can cause a psychological reaction known as "traumatic grief" that may become pathological and unresolved and, therefore, trigger a chronic post-traumatic stress disorder (PTSD). PTSD is thought to be common among police officers who have to face unexpected threatening events in a highly dangerous context (West et al. 2008; Bowler et al. 2016). In the police force, levels of stress vary considerably in relation with the type of task performed (Patterson 2001). Stressors are sometimes similar to those of other categories of workers. It has been shown that police officers who are assigned to administrative functions or traffic control may also experience high levels of chronic stress based on the organizational, bureaucratic, and procedural requirements of their work. They often complain about work overload, poor career opportunities, lack of resources and inadequate training, low income, difficulties in communicating with superiors, and the perception of being poorly supported by colleagues (Violanti and Aron 1994; Collins and Gibbs 2003; Juniper et al. 2010). In addition, since police activity has to cover 24 h a day, shift schedules may disrupt the circadian rhythm and reduce the quality/quantity of sleep, thus creating a further source of chronic stress when sufficient recovery time is not guaranteed (Garbarino 2014).

Chronic exposure to stressors in this population is associated with neuro-endocrine changes (Violanti et al. 2017), physical and mental illness (Arial et al. 2010; Arnetz et al. 2013; Garbarino et al. 2013), and may lead to absenteeism (Magnavita and Garbarino 2013a) or presenteeism (Leineweber et al. 2011; Taloyan et al. 2016) in a crucial sector for the safety of society. The magnitude of these phenomena in police sector can be probably underestimated, since the limited data available in the literature as well as the heterogeneity of sick leave measure that not allow comparisons between studies (Körlin et al. 2009). Moreover, it is noteworthy that police officers generally do not have a careful health examination including selected laboratory tests at appropriate intervals after their recruitment, and this prevents the early identification of work-related problems (Pira et al. 2016a).

Of course, being stress a complex and subjective factor, it is not possible to generalize. It has been shown that a single high risk event may be non-stressful (Garbarino et al. 2011). Comparing the levels of stress reported by various groups of workers, on the other hand, shows that police officers are not always more stressed than other employees (Magnavita and Garbarino 2013b).

Despite this hypothetical occupational risk, research regarding CVD in law enforcement personnel is limited, and not all studies demonstrate an increased mortality risk for this category of workers (Zimmerman 2012).

Here, we seek to address this issue by performing a systematic review of all observational studies on the associations between life stress, work stress, and the risk of metabolic syndrome and CVD in police.

## Materials and methods

This systematic review is based on the PRISMA statement (Moher et al. 2009). The focus of our question, which followed the PICO scheme, was: "Are police officers with an elevated level of perceived or occupational stress at high risk of metabolic syndrome and CVD in comparison to healthy controls?"

### Search strategies

The following databases were incorporated in the systematic search for relevant literature: PubMed, ISI Web of Science, Cinahl, and PsychInfo. The following search terms were used: (cops OR police OR police officer*) AND stress AND (metabolic syndrome OR hypertension OR obesity OR cholesterol OR hypercholesterolemia OR hypertriglyceridemia

OR diabetes OR ischemic heart disease OR cardiovascular disease). The electronic search was accompanied by a hand-search of the reference lists of the articles previously identified.

### Study inclusion and exclusion criteria

During the first stage of study selection, the titles and abstracts were screened and evaluated according to the following inclusion criteria: studies published in English between 1/1/2000 and 31/12/2016 with original data (observational, cross-sectional, cohort, and prospective studies) concerning the relationship between stress and CVD or metabolic diseases in police officers. To make a comprehensive evaluation of this issue, we also included studies that had investigated whether stress could trigger CVD development by altering the production of several pro- and anti-athero-genic proteins. Studies on other occupational groups (e.g., military police, firefighters, or other front-line occupations) were not included. Review studies were excluded, but their references were checked for inclusion. We included studies that focused on both cardiac and vascular diseases, their prevalence or incidence, and studies concerning risk factors for CVD, such as hypertension, hypercholesterolemia, hypertriglyceridemia, obesity, and diabetes. Studies that dealt exclusively with stress, its causes and psychosocial consequences, were not included; nor were those that had an outcome other than CVD. Studies that did not measure stress were also excluded.

### Study selection

As described in the flow chart (Fig. 1), the preliminary search retrieved 748 studies (311 in PubMed, 303 in ISI web of Science, 57 in Cinhal and 77 in PsycINFO). Four additional papers were included after evaluation of the review studies. Two independent investigators (IC and NM) first reviewed all titles/abstracts to identify potentially relevant articles. They then performed the study selection, based on a full-text review, according to inclusion/exclusion rules. Disagreements were resolved by discussion with a third researcher (SG). When full manuscript texts were not retrievable, the corresponding authors were contacted directly.

Overall a total of 752 potentially relevant titles, 220 duplicate studies had been excluded. 471 publications were excluded on the basis of the title, keywords, and abstract. A further 11 titles were excluded after a second abstract evaluation and discussion with the third reviewer. Two articles that met the inclusion criteria (Kamble and Phalke 2011; Violanti et al. 2006) were not available. After a thorough evaluation of 48 full-text articles, 32 papers were excluded, because they did not fulfill the inclusion criteria. Finally, 16 articles were selected for qualitative assessment (Fig. 1).

### Data extraction and quality assessment

Two investigators (IC and NM) independently extracted and inserted into a database the following information: study design, location, year, selection criteria of the sample, number of subjects enrolled with demographic characteristics, methods used for stress assessment, outcomes, adjustment

Two investigators (IC and NM) independently used the Newcastle–Ottawa Scale to evaluate the methodological quality of eligible studies. Disagreements between the authors were resolved by discussion with a third researcher (SG). A quality score was quantified according to three major components: selection of the groups of studies (0–4 points), quality of adjustment for confounding factors (0–2 points) and ascertainment of exposure or outcome of interest in the case–control or cohorts, respectively (0–3 points). The maximum score was 9 points, corresponding to the highest methodological quality (Tables 1, 2).variables and synthetic results.

### Evaluation of study quality and risk of bias

Study characteristics are summarized in Tables 1 and 2. Most studies (12; 75%) were cross-sectional, while 4 were prospective or retrospective cohort studies.

The average quality of the studies was low (mean score 3.3 points); quality score ranged from 2 to 6 on the nine-point Newcastle–Ottawa Scale. Sampling was the most frequent epidemiological problem. Studies generally adopted convenience sampling, without randomization. Sample dimensions in cross-sectional studies were often too small to accurately represent the respective police departments. Conversely, some longitudinal studies were conducted on large samples (Chen et al. 2015; Yu et al. 2016) or, if focused on small, highly selected police unit, included the total population and were, therefore, representative of the specific condition investigated (Garbarino and Magnavita 2015). Women were often excluded from the analysis due to their limited number, although the proportion of female police officers can no longer be considered negligible due to a rapid rise in this occupational category in recent years.

Only six studies (Franke et al. 2002, 2010; Maia et al. 2008; Ramey 2003; Walvekar et al. 2015; Wright et al. 2011) had a control group. However, in these studies, controls were not always drawn from the same community as the exposed cohort. Two papers made use of an internal control group by dividing the observed group of police officers into a “high” and “low” level of exposure, based upon measurement of self-perceived stress (Walvekar et al. 2015) or presence of PTSD symptoms (Maia et al. 2008). Other studies, at last, only studied the distribution of the scores of a questionnaire within the group.

Exposure was always ascertained by means of questionnaires. The term stress is used with different meanings in the studies and questionnaires were designed to measure two types of stress: general and work-related stress. The interviews were conducted by phone, or took place during medical examination. With regard to the outcome, some studies adopted as outcome CVD diagnosis, or its symptoms and signs, while the majority evaluated metabolic CV risk factors such as hypertension, hyperlipidemia, diabetes, and obesity that contribute to metabolic syndrome (MetS). CV risk factors were generally physically evaluated through laboratory tests, except in the study of Franke et al. (2002) and Ramey (2003), which relied on self-reported information. Conversely, data on CV morbidity were self-reported in almost all studies, and objectively verified (through radiologic and ultrasound imaging of coronary and carotid arteries and exercise ECG) in only one study (Janczura et al. 2015). Most of the studies did not adjust for confounding risk factors.

## Results

### Association between stress and MetS

The association between stressful life events and MetS was studied in two cross-sectional studies. An American study conducted on 386 police officers observed a higher prevalence of MetS in workers with a higher perceived stress score than the lower score group, but the difference was not significant (Yoo et al. 2009). A weak but significant association between self-perceived life stress and the prevalence of MetS (OR 1.07 95% CI 1.03–1.13 $p = 0.03$ per one-point score change of the questionnaire) was observed in a convenience sample of 235 Polish officers (Janczura et al. 2015).

Only one longitudinal study evaluated the incidence of MetS in a flying squad of Italian police officers engaged in highstress law enforcement activities. Work stress was continuously assessed for 5 years by means of the demand–control–support model of Karasek (1979) and the effort–reward imbalance model of Siegrist (1996). The metabolic profile was assessed at baseline and at follow-up. In this cohort, police officers in the highest quartile of stress scores had an increased adjusted risk of developing MetS (OR 2.68 95% CI 1.08–6.70 $p < 0.05$). Demand and Effort were significant predictors of MetS (Garbarino and Magnavita 2015).

### Association between stress and the components of MetS

**Stress and hypertension**

Eight studies provided information concerning the relationship between chronic stress and hypertension (Franke et al. 2002; Ganesh et al. 2014; Garbarino and Magnavita 2015; Hartley et al. 2011; Janczura et al. 2015; Ramakrishnan et al. 2013; Ramey 2003; Walvekar et al. 2015). Only two studies had a longitudinal design (Garbarino and Magnavita 2015; Wright et al. 2011). Two different definitions of stress were given: five studies evaluated the degree to which life events were judged to be stressful (self-perceived life stress), three studies evaluated exposure to work-related stress. Most of the available studies evaluated blood pressure after a short rest during clinical examination; in two studies, hypertension was self-reported (Franke et al. 2002; Ramey 2003).

Among studies concerning perceived life stress, three cross-sectional and one longitudinal study showed an association between stress and hypertension, while one study failed to find any statistical significance.

In the aforementioned Polish sample (216 men, 19 women), perceived life stress was significantly associated with systolic ($p = 0.01$) and diastolic ($p = 0.03$) blood pressure (Janczura et al. 2015).

A significant correlation between self-reported general stress and hypertension was observed among 2,818 male law enforcement officers enrolled from nine North American states (Franke et al. 2002; Ramey 2003). Perceived stress was associated with diastolic blood pressure ($\beta = 0.16$; $p = 0.039$), but not with systolic blood pressure in a sample of 105 male American middle-aged law enforcement officers who were followed for almost 7 years (Wright et al. 2011). A significant association between stress levels and hypertension (aOR 2.89, 95% CI 1.42–5.84) was reported by Ramakrishnan et al. (2013) in a survey carried out on a group of Indian policemen (256), mostly police constables. Another Indian study observed an association between a moderate level of perceived stress and the risk of having high blood pressure (aOR 2.37 95% CI 1.24–4.53), but there was no linearity between stress levels and hypertension (Ganesh et al. 2014).

Conversely, the study of Walvekar et al. (2015), that divided 108 male Indian police constables into two groups by stress score, found no significant difference in average blood pressure values between stressed and non-stressed officers. Hartley et al. (2011) failed to find an association between work-related stress and hypertension in 102 female officers from the BCOPS (Buffalo Cardio-metabolic Occupational Police Study). No significant increase in the incidence of hypertension was found in the aforementioned Italian prospective study on a small sample of policemen followed for 5 years (Garbarino and Magnavita 2015).

**Stress and obesity**

Data concerning the relationship between stress and adiposity were extrapolated from five studies: three measured “general perceived stress” (Janczura et al. 2015; Walvekar et al. 2015; Wright et al. 2011) and two “work-related stress” (Garbarino and Magnavita 2015; Hartley et al. 2011).

As outcome variables, one study measured waist circumference (WC), three both WC and body mass index (BMI), and one the waist/hip ratio.

The level of perceived stress appeared to be correlated with WC ($r = 0.17$, $p = 0.03$) in the polish sample (Janczura et al. 2015) and in the sample of 105 middle-aged American police officers who were followed over a 7-year time span (Wright et al. 2011). A significant association between work-related stress and abdominal obesity (OR 1.37, 95% CI 1.04–1.81) was also found in the BCOPS cross-sectional study (Hartley et al. 2011). Conversely, no significant association was found between stress and obesity in the cross-sectional study of Walvekar et al. (2015) nor in the longitudinal study of Garbarino and Magnavita (2015).

**Stress and dyslipidemia**

Six studies examined the influence of work stress (Garbarino and Magnavita 2015; Hartley et al. 2011), post-traumatic stress (Maia et al. 2008), and perceived life stress (Chen et al. 2015; Janczura et al. 2015; Walvekar et al. 2015) on dyslipidemia, defined as high total cholesterol (> 200 mg/ dL), or low high-density lipoprotein cholesterol (HDL-C) (< 40 mg/dL) or elevated triglycerides (> 150 mg/dL).

The results of the cross-sectional studies on perceived stress were conflicting. Janczura et al. (2015) found a significant correlation between a high score on the perceived stress scale and triglyceride plasma levels ($r = 0.19$, $p = 0.002$); conversely Walvekar et al. (2015) failed to find an association between stress and lipid levels.

The longitudinal study that evaluated the impact of psychological distress on dyslipidemia among 3300 Chinese police officers (criminal investigators, traffic controllers, public security, etc..) found a significant association between psychological distress and incident dyslipidemia (HR = 1.15; 95% CI 1.05–1.26) after a 4-year follow-up. Traffic controllers in this cohort had a higher rate of incident dyslipidemia compared to policemen assigned to other duties (Chen et al. 2015).

Studies on work-related stress consistently reported an association. The cross-sectional study on female BCOPS of Hartley et al. (2011) found a significant association between self-reported work-related stress and elevated triglycerides (OR = 1.57, 95% CI 1.02–2.43) and low HDL-C (OR = 1.33, 95% CI 1.06–1.69). The longitudinal study on Italian police officers showed an association between high work stress level and increased incidence of hypertriglyceridemia (aOR 7.86, 95% CI 1.29–48.04). The observed sample was, however, rather small, and the confidence intervals (CI) of the study are too wide to allow for a safe interpretation. The HDL-C mean level was lower in the high-stress group than the low-stress officers, but the difference in incident hypercholesterolemia failed to reach significance (aOR 1.57, 95% CI 0.40–6.25 ns) (Garbarino and Magnavita 2015).

A study of 118 members of a highly trained unit of the Brazilian police force, which was deployed only in critical situations, found that police officers who suffered from PTSD after acute traumatic events had significantly higher total cholesterol and triglyceride concentrations than those without PTSD, after controlling for age, educational level, BMI, tobacco, alcohol use, and beta-blockers (Maia et al. 2008).

**Stress and glucose metabolism**

Walvekar et al. (2015) suggested that chronic life stress could affect glucose metabolism, since they observed a significant difference in fasting blood glucose and glycosylated hemoglobin levels between stressed male Indian police constables (41 persons) and the non-stressed group (67 persons).

In the aforementioned Buffalo study, lack of support at work was positively associated with the risk of having glucose intolerance in a group of 102 female police officers (OR 1.37 95% CI 1.01–1.84) (Hartley et al. 2011).

Two studies addressed prospectively the association between chronic work stress and incidence of diabetes in Italian and Chinese police officers, respectively. Both studies showed an increased incidence of glucose intolerance that was not significant in the small Italian cohort (Garbarino and Magnavita 2015), but highly significant in the larger Chinese study that enrolled 5811 police officers (traffic controllers, criminal investigators, public security agent, and others) who were followed for 4 years (Yu et al. 2016). Specific stress factors, such as role overload (RO), role boundary (RB), physical environment (PE), interpersonal strain (IS), and physical strain (PHS) were associated with the incidence of diabetes after adjustment for confounding factors.

**Association between stress and CVD or markers of disease**

The studies that investigated the relationship between stress and CV risk were divided into two groups: four collected data on CV morbidity by interviewing law enforcement officers (Franke et al. 2002; Janczura et al. 2015; Ramey 2003; Ramey et al. 2011) and two determined the levels of pro- and anti-atherogenic markers implicated in the pathogenesis and clinical course of atherosclerotic vascular disease (Franke et al. 2010; Ramey et al. 2012).

In their studies on 2,818 male officers (mean age 37.3 years), enrolled from nine North American states, Franke et al. (2002), and subsequently Ramey (2003) found an association between self-reported stress and CVD morbidity ($\eta 2$ = 0.003; p = 0.008). Interestingly, perceived stress levels were affected significantly by duration of time in the law enforcement profession (p = 0.004) while CVD by age only (p = 0.022).

A statistically significant association between perceived general stress and self-reported CVD (angina, stroke or myocardial infarction) was also found by Ramey et al. (2011) in a convenience sample of 272 urban police officers from the Midwest of the USA (OR 1.20, 95% CI 1.03–1.39). The same study also observed an association between vital exhaustion and CVD (OR 1.31, 95% CI 1.12–1.53).

In a convenience sample, Janczura et al. (2015) found a barely significant association between perceived stress and the prevalence of coronary plaque (Or = 1.05, 95% CI 1.001–1.10, p = 0.04).

Studies on work stress and biological change of proand anti-atherogenic markers were performed by American researchers. In the first study (Franke et al. 2010), the research group measured circulating levels of inflammatory markers and the perception of chronic stress in a convenience group of 444 law enforcement officers from Iowa, and in a smaller comparison group from the general population.

Even if cytokines IL-1β, IL-6, TNF-α were significantly higher in officers than in controls, indicating a more pronounced pro-inflammatory effect, no significant association between stress levels and inflammatory mediators was found.

Another study carried out on a smaller sample of policemen (71 persons) reported that interleukins (IL-6 and IL-4) were significantly related to perceived stress, and IL-1β and IL-4 were associated with job demand (Ramey et al. 2012).

## Discussion

Data from literature showed that police officers' exposure to stress was inconstantly associated with hypertension, obesity, dyslipidaemia, impaired glucose metabolism, and MetS. In addition, some studies showed an association between stress and CVD morbidity. Studies of higher quality, such as longitudinal studies on large sample size (thousands of subjects) or on homogenous group of police officers, whose stress levels were regularly monitored, were more supportive of a significant positive association between stress and CV risk factors.

These findings can be compared with those of the previous reviews and meta-analysis on the influence of stress on CVD outcomes among different group of workers or general population.

A recent review of studies on over 600,000 men and women from 27 cohort studies in Europe, the USA and Japan suggests that work stressors, such as job strain and long working hours, are associated with a moderately elevated risk of incident coronary heart disease and stroke. The excess risk for exposed individuals is 10–40% compared with subjects in whom such stressors are absent (Kivimäki and Kawachi 2015).

An overview of two systematic reviews on work-related stress concluded that there was modest (1.32, 95% CI 1.09–1.59; Virtanen et al. 2013) to moderate evidence (1.45, 95% CI 1.15–1.84; Kivimäki et al. 2006) of an association between psychosocial stress at work and CV outcomes (Fishta and Backé 2015; Kivimäki et al. 2006; Virtanen et al. 2013). In line with the results of the previous reviews, Wilson et al. (2014) found a significant positive association between work-related stress and risk of atherosclerosis, assessed via carotid intima–media thickness (CIMT) evaluation. A meta-analysis

focused on workers who had an acute coronary heart disease (CHD) event, indicated that work stress increase the risk of developing recurrent CVD events by 65% (Li et al. 2015).

Regarding CV risk factors, a systematic review of 39 prospective cohort studies supported an association between chronic psychosocial stress and the development of MetS (Bergmann et al. 2014).

With respect to hypertension, a review providing an updated synthesis of the literature from 2010 to April 2014 found an association between occupational stress and blood pressure (Cuffee et al. 2014). A more consistent adverse effect was observed among men than women and in studies of higher methodological quality (Babu et al. 2014; Gilbert- Ouimet et al. 2014; Landsbergis et al. 2013). In line with this review, researchers have observed a trend toward a positive association between work-related stress and dyslipidemia as well as impaired glucose metabolism, although the number of studies is not enough to make a definite statement (Bergmann et al. 2014).

The association of stress with weight gain observed in many studies included in this review do not seem to agree with a recent review that failed to find evidence to support the hypothesis that job strain is a risk factor for obesity (Kivimäki et al. 2015).

This review is the first attempt that has been made to identify and critically assess published studies that investigated the relationship between stress and CVD in police officers.

Although most studies included in this review concluded that there was an association between stress and CVD as well as CV risk factors and these findings are consistent with current scientific knowledge, the evidence supporting an increase in CV risk in police officer due to high level of perceived stress is rather weak.

Results were, however, often conflicting and inconsistent with regard to definitions and measurement of stress, features of individual study design, study conduct, and conclusions drawn.

The epidemiological weaknesses of most cross-sectional studies, the scarcity of longitudinal studies and the different definitions adopted for both exposure (life stress, perceived stress, work-related chronic and acute stress) and outcome (CV morbidity, CV risk factors) may have affected the study findings and require a cautious interpretation. The heterogeneous nature and limited number of studies prevented us from performing a quantitative data synthesis in the way of meta-analysis.

The definition of exposure is undoubtedly the most critical aspect. Stress is challenging to readily and objectively measured, because it is based upon individual perception and may fluctuate over the time. Although we were interested in evaluating the impact of occupational stress on CVD risk among police officers, most of the studies available provided a general non-specific measure of perceived stress that included both general and occupational stress. Furthermore, except for one study (Garbarino and Magnavita 2015), the measurement of stress in a single time point (generally at the beginning of the study) does not allow to evaluate changes in exposure, nor to identify chronically exposed subjects who could have a higher CV risk than controls. The number of subjects recruited in many studies is modest, and often, convenience samples are used. Women are often under-represented and the issue of gender health in police has never been studied.

As we mentioned above, police officers experience frequent ad ongoing job stressors including those unique to their profession (exposure to aggression and violence) and those similar to the type of stressors present in other occupational categories (organizational, bureaucratic, and procedural). Operational stressors, which deal with violent situations, had a highly emotional impact but they occur less frequent than organizational stressors that, therefore, may be perceived as more stressful than the former (Collins and Gibbs 2003; Violanti et al. 2016). None of the studies included in this review have assessed the individual emotional response to both acute and chronic work-related stressful conditions, thus making it difficult to determine to what extent work-related psychosocial factors in police work enhance the risk for CVD. In addition, studies tend to homogenize police officers into very broad categories and do not consider the relevance or

importance of within-group stressors that depend on the kind of task they performed and determine the level of perceived stress for each police section. In fact, the police officers performed a vast number of tasks, some of which may expose them to stressful emotional factors, while those dealing mainly with administrative tasks have a very different risk profile.
Another general challenge in interpreting occupational epidemiology studies on police officers is that of selection.
Police officers are selected according to their capacity to cope with stress. At the entry, they underwent a personality and physical testing to prove if they had the appropriate characteristics for fulfilling the role of police officers. Therefore, they showed higher level of physical and mental health compared to general population (Garbarino et al. 2013). Studies on police officers exclusively devoted to law enforcement showed that they have a prevailing personality pattern of high stability/low neuroticism, which is in turn associated with high resilience and moderates the effects of workload (Chiorri et al. 2015; Garbarino et al. 2012, 2014).
In addition, over the years of service workers with known cardiac disease may self-select into jobs with lesser degrees of work-related stress or leave the work force entirely. Workers in high strain jobs who subsequently develop cardiac disease may shift out of those positions to new ones with potential lower degrees of work-related stress.

## Conclusion

In view of these findings, further well-designed studies, based on randomized samples and comparable controls, are needed.
Although there is still no firm evidence of the association between police stress and CVD, a sound precautionary principle would be to adopt worksite health promotion programs designed to implement stress management strategies and improve the lifestyle and eating habits of this category of workers.
Based on this principle, the Italian Association of Occupational Health (SIMLII) issued in 2016 a set of guidelines for health surveillance of police that recommend a holistic assessment of workers aimed at promoting health and maintaining well-being (Pira et al. 2016b). These guidelines were adopted by the Italian State Police and implemented in 2017.
The early identification of subjects at risk and the screening for psychological and psychiatric disorders are essential to prevent disease and establishing effective improvement of health levels, as well as proper treatment of CV and metabolic diseases.

## Compliance with ethical standards

Conflict of interest The study was not funded. The authors declare that they have no conflict of interest.

**References**


1. Arial M, Gonik V, Wild P, Danuser B (2010) Association of work related chronic stressors and psychiatric symptoms in a Swiss sample of police officers; a cross sectional questionnaire study. Int Arch Occup Environ Health 83:323–331
2. Arnetz BB, Arble E, Backman L, Lynch A, Lublin A (2013) Assessment of a prevention program for work-related stress among urban police officers. Int Arch Occup Environ Health 86(1):79–88. https://doi.org/10.1007/s00420-012-0748-6
3. Babu GR, Jotheeswaran AT, Mahapatra T, Mahapatra S, Kumar A Sr, Detels R, Pearce N (2014) Is hypertension associated with job strain? A meta-analysis of observational studies. Occup Environ Med 71(3):220–227. https://doi.org/10.1136/oemed-2013-101396
4. Bellisarii FL, Gallina S, De Caterina R (2001) Tumor necrosis factor-alpha and cardiovascular diseases. Ital Heart J 2(6):408–417
5. Bergmann N, Gyntelberg F, Faber J (2014) The appraisal of chronic stress and the development of the metabolic syndrome: a systematic review of prospective cohort studies. Endocr Connect 3(2):R55–R80. https://doi.org/10.1530/EC-14-0031
6. Bowler RM, Kornblith ES, Li J, Adams SW, Gocheva VV, Schwarzer R, Cone JE. (2016) Police officers who responded to 9/11: Comorbidity of PTSD, depression, and anxiety 10–11 years later. Am J Ind Med. 59(6):425–436. https://doi.org/10.1002/ajim.22588
7. Chandola T, Britton A, Brunner E, Hemingway H, Malik M, Kumari M, Badrick E, Kivimaki M, Marmot M (2008) Work stress and coronary heart disease: what are the mechanisms? Eur Heart J 29(5):640–648. https://doi.org/10.1093/eurheartj/ehm584
8. Chen X, Leng L, Yu H, Yang XL, Dong GH, Yue S, Chen JS, Tang NJ (2015) Psychological distress and dyslipidemia in Chinese police officers: a 4-year follow-up study in Tianjin, China. J Occup Environ Med 57(4):400–405. https://doi.org/10.1097/ JOM.0000000000000372
9. Chiorri C, Garbarino S, Bracco F, Magnavita N (2015) Personality traits moderate the effect of workload sources on perceived workload in flying column police officers. Front Psychol 6:1835. https://doi.org/10.3389/fpsyg.2015.01835
10. Collins PA, Gibbs AC (2003) Stress in police officers: a study of the origins, prevalence and severity of stress-related symptoms within a county police force. Occup Med (Lond) 53(4):256–264
11. Cuffee Y, Ogedegbe C, Williams NJ, Ogedegbe G, Schoenthaler A (2014) Psychosocial risk factors for hypertension: an update of the literature. Curr Hypertens Rep 16(10):483. https://doi.org/10.1007/s11906-014-0483-3
12. Dragano N, Siegrist J, Nyberg ST, Lunau T, Fransson EI, Alfredsson L, Bjorner JB, Borritz M, Burr H, Erbel R, Fahlén G, Goldberg M, Hamer M, Heikkilä K, Jöckel KH, Knutsson A, Madsen IE, Nielsen ML, Nordin M, Oksanen T, Pejtersen JH, Pentti J,Rugulies R, Salo P, Schupp J, Singh-Manoux A, Steptoe A, Theorell T, Vahtera J, Westerholm PJ, Westerlund H, Virtanen M, Zins M, Batty GD, Kivimäki M (2017) IPD-Work consortium. Effortreward imbalance at work and incident coronary heart disease: a multi-cohort study of 90,164 individuals. Epidemiology. https://doi.org/10.1097/EDE.0000000000000666
13. Fishta A, Backé EM (2015) Psychosocial stress at work and cardiovascular diseases: an overview of systematic reviews. Int Arch Occup Environ Health 88(8):997–1014. https://doi.org/10.1007/ s00420-015-1019-0

14. Franke WD, Ramey SL, Shelley MC 2nd (2002) Relationship between cardiovascular disease morbidity, risk factors, and stress in a law enforcement cohort. J Occup Environ Med 44(12):1182–1189
15. Franke WD, Kohut ML, Russell DW, Yoo HL, Ekkekakis P, Ramey SP (2010) Is job-related stress the link between cardiovascular disease and the law enforcement profession? J Occup Environ Med 52(5):561–565. https://doi.org/10.1097/JOM.0b013e3181dd086b
16. Ganesh KS, Naresh AG, Bammigatti C (2014) Prevalence and risk factors of hypertension among male police personnel in Urban Puducherry, India. Kathmandu Univ Med J (KUMJ) 12(48):242–246
17. Garbarino S (2014) 24-hour work: the interaction of stress and changes in the sleep-wake cycle in the police force. G Ital Med Lav Ergon 36(4):392–396
18. Garbarino S, Magnavita N (2015) Work stress and metabolic syndrome in police officers. a prospective study. PLoS One 10(12):e0144318. https://doi.org/10.1371/journal.pone.0144318
19. Garbarino S, Magnavita N, Elovainio M, Heponiemi T, Ciprani F, Cuomo G, Bergamaschi A (2011) Police job strain during routine activities and a major event. Occup Med (Lond) 61(6):395–399
20. Garbarino S, Chiorri C, Magnavita N, Piattino S, Cuomo G (2012) Personality profiles of special force police officers. J Police Crim Psychol 27(2):99–110. https://doi.org/10.1007/s11896-011-9099-6
21. Garbarino S, Cuomo G, Chiorri C, Magnavita N (2013) Association of work-related stress with mental health problems in a special police force. BMJ Open. https://doi.org/10.1136/bmjopen-2013-002791
22. Garbarino S, Chiorri C, Magnavita N (2014) Personality traits of the Five-Factor Model are associated with work-related stress in special force police officers. Int Arch Occup Environ Health 87(3):295–306. https://doi.org/10.1007/s00420-013-0861-1
23. Gilbert-Ouimet M, Trudel X, Brisson C, Milot A, Vézina M (2014) Adverse effects of psychosocial work factors on blood pressure: systematic review of studies on demand-control-support and effort-reward imbalance models. Scand J Work Environ Health 40(2):109–132. https://doi.org/10.5271/sjweh.3390
24. Hartley TA, Burchfiel CM, Fekedulegn D, Andrew ME, Knox SS, Violanti JM (2011) Associations between police officer stress and the metabolic syndrome. Int J Emerg Ment Health 13(4):243–256
25. Janczura M, Bochenek G, Nowobilski R, Dropinski J, Kotula-Horowitz K, Laskowicz B, Stanisz A, Lelakowski J, Domagala T (2015) The relationship of metabolic syndrome with stress, coronary heart disease and pulmonary function–an occupational cohort-based study. PLoS One 10(8):e0133750. https://doi.org/10.1371/journal.pone.0133750
26. Juniper B, White N, Bellamy P (2010) A new approach to evaluating the well-being of police. Occup Med (Lond) 60(7):560–565. https://doi.org/10.1093/occmed/kqq130
27. Kamble SV, Phalke DB (2011) Study of occupational stress as a risk factor for various morbidities among policemen. J Indian Med Assoc 109(4):238–240
28. Kanda T, Takahashi T (2004) Interleukin-6 and cardiovascular diseases. Jpn Heart J 45(2):183–193
29. Karasek R (1979) Job control, job decision latitude and mental strain. Implications for job redesign. Adm Sci Q 24:285–306
30. Kivimäki M, Kawachi I (2015) Work stress as a risk factor for cardiovascular disease. Curr Cardiol Rep 17(9):630. https://doi.org/10.1007/s11886-015-0630-8
31. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Vaananen A, Vahtera J (2006) Work stress in the etiology of coronary heart disease- a meta-analysis. Scand J Work Environ Health 32:431–442. https://doi.org/10.5271/sjweh.1049

32. Kivimäki M, Singh-Manoux A, Nyberg S, Jokela M, Virtanen M (2015) Job strain and risk of obesity: systematic review and metaanalysis of cohort studies. Int J Obes (Lond) 39(11):1597–1600. https://doi.org/10.1038/ijo.2015.103
33. Körlin J, Alexanderson K, Svedberg P (2009) Sickness absence among women and men in the police: a systematic literature review. Scand J Public Health 37(3):310–319
34. Landsbergis PA, Dobson M, Koutsouras G, Schnall P (2013) Job strain and ambulatory blood pressure: a meta-analysis and systematic review. Am J Public Health 103(3):e61–e71. https://doi.org/10.2105/AJPH.2012.301153
35. Leineweber C, Westerlund H, Hagberg J, Svedberg P, Luokkala M, Alexanderson K (2011) Sickness presenteeism among Swedish police officers. J Occup Rehabil 1:17–22. https://doi.org/10.1007/s10926-010-9249-1
36. Li J, Zhang M, Loerbroks A, Angerer P, Siegrist J (2015) Work stress and the risk of recurrent coronary heart disease events: a systematic review and meta-analysis. Int J Occup Med Environ Health 28(1):8–19. https://doi.org/10.2478/s13382-014-0303-7
37. Magnavita N, Garbarino S (2013a) Is absence related to work stress? A repeated cross-sectional study on a special police force. Am J Ind Med 56(7):765–775. https://doi.org/10.1002/ajim.22155
38. Magnavita N, Garbarino S (2013b) Social psychiatry in the waiting room. What a physician can learn about occupational stress from workers waiting to be examined. Psychiatry J 2013:701872. https://doi.org/10.1155/2013/701872
39. Maia DB, Marmar CR, Mendlowicz MV, Metzler T, Nóbrega A, Peres MC, Coutinho ES, Volchan E, Figueira I (2008) Abnormal serum lipid profile in Brazilian police officers with post-traumatic stress disorder. J Affect Disord 107(1–3):259 – 63
40. Moher D, Liberati A, Tetzlaff J, Altman DG (2009) PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097
41. Patterson GT (2001) The relationship between demographic variables and exposure to traumatic incidents among police officers. Austr J Disaster Trauma Stud. http://www.massey.ac.nz/~trauma/issues/2001-2/patterson2.htm
42. Pira E, Garbarino S, Ciprani F, De Lorenzo G, Mennoia NV, Proto E, Roca A, Magnavita N (2016a) Linee-Guida SIMLII sulla sorveglianza sanitaria delle Forze dell'Ordine italiane: un vuoto da colmare. Mel Lav 107(2):153–158
43. Pira E, Garbarino S, Magnavita N, Ciprani F, De Lorenzo G, Garzaro G, Mennoia NV, Proto E, Roca A (2016b) Linee Guida per la Sorveglianza Sanitaria degli operatori dei Corpi di Polizia. Nuova Editrice Berti, Piacenza (ISBN 978–88-7643-706-5)
44. Ramakrishnan J, Majgi SM, Premarajan KC, Lakshminarayanan S, Thangaraj S, Chinnakali P (2013) High prevalence of cardiovascular risk factors among policemen in Puducherry, South India. J Cardiovasc Dis Res 4(2):112–115
45. Ramey SL (2003) Cardiovascular disease risk factors and the perception of general health among male law enforcement officers: encouraging behavioral change. AAOHN J 51(5):219 – 26
46. Ramey SL, Perkhounkova Y, Downing NR, Culp KR (2011) Relationship of cardiovascular disease to stress and vital exhaustion in an urban. Midwest Police Dep AAOHN J 59(5):221–227. https://doi.org/10.3928/08910162-20110418-02

47. Ramey SL, Downing NR, Franke WD, Perkhounkova Y, Alasagheirin MH (2012) Relationships among stress measures, risk factors, and inflammatory biomarkers in law enforcement officers. Biol Res Nurs 14(1):16–26. https://doi.org/10.1177/1099800410396356
48. Siegrist J (1996) Adverse health effects of high-effort/low-reward conditions. J Occup Health Psychol 1(1):27–41
49. Siegrist J (2001) Psychosocial factors influencing development and course of coronary heart disease. Herz. 26(5):316–325
50. Taloyan M, Kecklund G, Thörn L, Kjeldgård L, Westerlund H, Svedberg P, Alexanderson K. (2016) Sickness presence in the Swedish Police in 2007 and in 2010: Associations with demographic factors, job characteristics, and health. Work 54(2):379–387. https://doi.org/10.3233/WOR-162333
51. Ueyama T, Senba E, Kasamatsu K, Hano T, Yamamoto K, Nishio I, Tsuruo Y, Yoshida K (2003) Molecular mechanism of emotional stress-induced and catecholamine-induced heart attack. J Cardiovasc Pharmacol 41(Suppl 1):S115–S118
52. Van Tassell BW, Raleigh JM, Abbate A (2015) Targeting interleukin-1 in heart failure and inflammatory heart disease. Curr Heart Fail Rep 12(1):33–41. https://doi.org/10.1007/s11897-014-0231-7
53. Violanti JM, Aron F (1994) Ranking police stressors. Psychol Rep 75(2):824–826
54. Violanti JM, Fekedulegn D, Hartley TA, Andrew ME, Charles LE, Mnatsakanova A, Burchfiel CM (2006) Police trauma and cardiovascular disease: association between PTSD symptoms and metabolic syndrome. Int J Emerg Ment Health 8(4):227–237
55. Violanti JM, Fekedulegn D, Hartley TA, Charles LE, Andrew ME, Ma CC, Burchfiel CM (2016) Highly rated and most frequent stressors among police officers: gender differences. Am J Crim Justice 41(4):645–662. https://doi.org/10.1007/s12103-016-9342-x
56. Violanti JM, Fekedulegn D, Andrew ME, Hartley TA, Charles LE, Miller DB, Burchfiel CM (2017) The impact of perceived intensity and frequency of police work occupational stressors on the cortisol awakening response (CAR): findings from the BCOPS study. Psychoneuroendocrinology 75:124–131. https://doi.org/10.1016/j.psyneuen.2016.10.017
57. Virtanen M, Nyberg ST, Batty GD, Jokela M, Heikkilä K, Fransson EI, Alfredsson L, Bjorner JB, Borritz M, Burr H, Casini A, Clays E, De Bacquer D, Dragano N, Elovainio M, Erbel R, Ferrie JE, Hamer M, Jöckel KH, Kittel F, Knutsson A, Koskenvuo M, Koskinen A, Lunau T, Madsen IE, Nielsen ML, Nordin M, Oksanen T, Pahkin K, Pejtersen JH, Pentti J, Rugulies R, Salo P, Shipley MJ, Siegrist J, Steptoe A, Suominen SB, Theorell T, Toppinen-Tanner S, Väänänen A, Vahtera J, Westerholm PJ, Westerlund H, Slopen N, Kawachi I, Singh-Manoux A, Kivimäki M (2013) IPD-Work Consortium. Perceived job insecurity as a risk factor for incident coronary heart disease: systematic review and meta-analysis. BMJ 347:f4746. https://doi.org/10.1136/bmj.f4746
58. Walvekar SS, Ambekar JG, Devaranavadagi BB (2015) Study on serum cortisol and perceived stress scale in the police constables. J Clin Diagn Res 9(2):BC10–B4. https://doi.org/10.7860/JCDR/2015/12015.5576
59. West C, Bernard B, Mueller C, Kitt M, Driscoll R, Tak S (2008) Mental health outcomes in police personnel after Hurricane Katrina. J Occup Environ Med 50(6):689 – 95. https://doi.org/10.1097/JOM.0b013e3181638685
60. Wilson MD, Conroy LM, Dorevitch S (2014) Occupational stress and subclinical atherosclerosis: a systematic review. Int J Occup Environ Health 20(4):271 – 80. https://doi.org/10.1179/2049396714Y.0000000076

61. Wright BR, Barbosa-Leiker C, Hoekstra T (2011) Law enforcement officer versus non-law enforcement officer status as a longitudinal predictor of traditional and emerging cardiovascular risk factors. J Occup Environ Med 53(7):730–734. https://doi.org/10.1097/ JOM.0b013e318220c2da
62. Yoo HL, Eisenmann JC, Franke WD (2009) Independent and combined influence of physical activity and perceived stress on the metabolic syndrome in male law enforcement officers. J Occup Environ Med 51(1):46–53. https://doi.org/10.1097/JOM.0b013e31817f9e43
63. Yu H, Liu JC, Fan YJ, Li C, Zhang LX, Chen X, Yue S, Lu WL, Yang XL, Tang NJ (2016) Association between occupational stressors and type 2 diabetes among Chinese police officers: a 4-year follow-up study in Tianjin, China. Int Arch Occup Environ Health 89(2):277–288. https://doi.org/10.1007/s00420-015-1071-9
64. Zimmerman FH (2012) Cardiovascular disease and risk factors in law enforcement personnel: a comprehensive review. Cardiol Rev 20(4):159–166. https://doi.org/10.1097/CRD.0b013e318248d631

**Figure 1: Systematic literature review process**

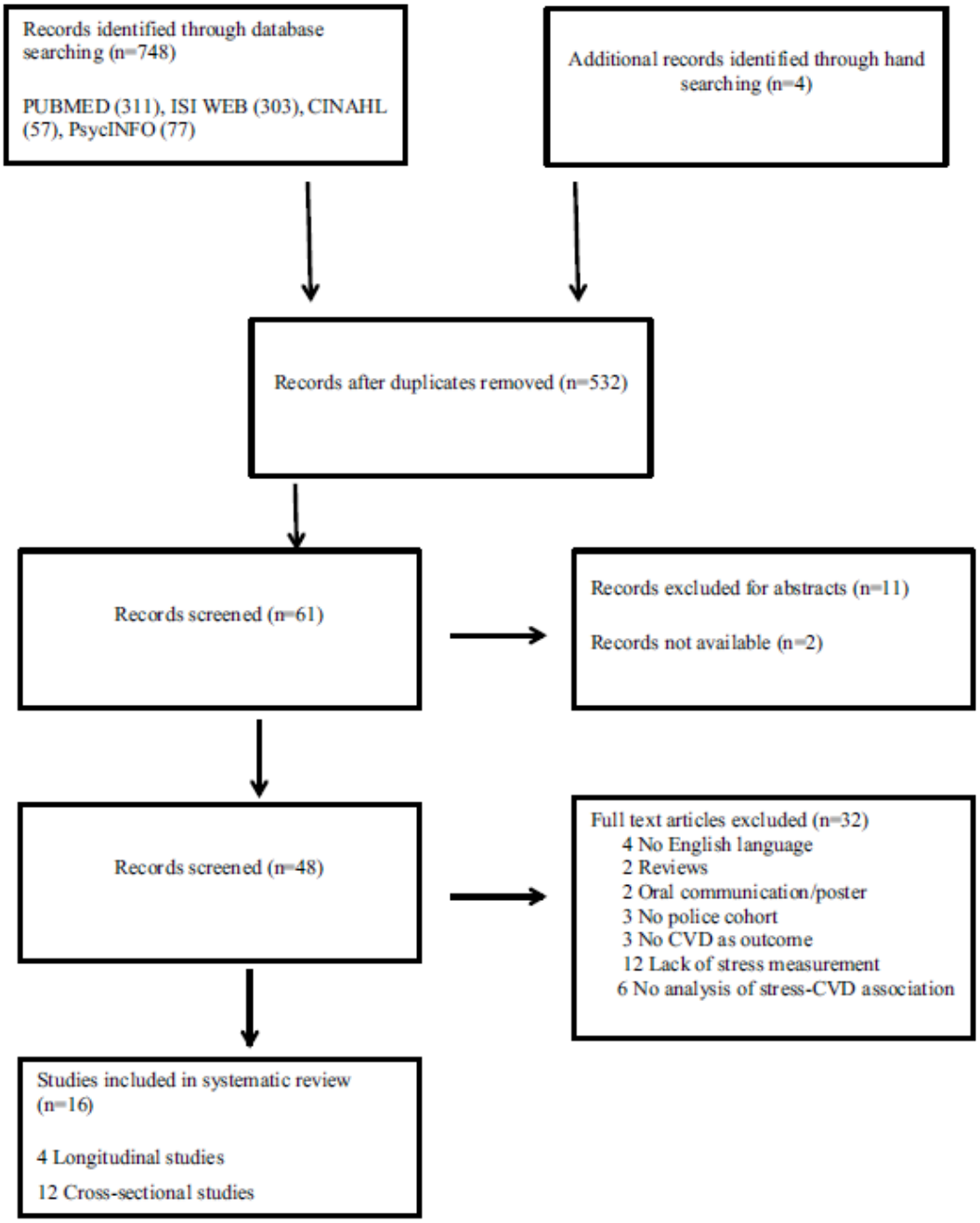

**Table 1** Studies concerning the relationship between stress and metabolic syndrome or its components

| References | Study design | Study quality | Sample size (location) | Population (mean age or age range) | Controls (*n*, mean age) | Exposure (questionnaire) | Outcome | Adjustment variables | Main results |
|---|---|---|---|---|---|---|---|---|---|
| Yoo et al. (2009) | Cross-sectional | ☆☆☆☆ | 386 M (USA) | Sworn police officers (23–60 years) | – | PSS score | MetS | – | Regression coefficient $r=0.047$ ($p>0.05$) |
| Hartley et al. (2011) | Cross-sectional | ☆☆☆ | 390, 288 M, 102 F (USA) | Sworn police officers (41 years) | – | Spielberger Police Stress Survey | CV risk factors | – | Women: abdominal obesity OR 1.37 (95% CI 1.04–1.81); elevated triglycerides: OR 1.57(95% CI 1.02–2.43); low HDL OR 1.33 (95% CI 1.06–1.69) |
| Ramakrishnan et al. (2013) | Cross-sectional | ☆☆☆ | 256 M (India) | Police constables (40.9 years) | – | Professional life stress score questionnaire | Hypertension | Age, gender, BMI | Stress was associated with hypertension (aOR 2.89, 95% CI 1.42–5.84) ($p=0.003$) |
| Ganesh et al. (2014) | Cross-sectional | ☆☆☆ | 296 (India) | Police officers with hypertension (25–59 years) | – | Cohen's Perceived Stress scale | Hypertension | – | OR (95% CI) (*p* value)<br>Very High:1.48 (0.35–6.21) (0.58)<br>High: 2.21 (0.84–5.8) (0.10)<br>Moderate: 2.37 (1.2–4.53) (0.009) |
| Walvekar et al. (2015) | Cross-sectional | ☆☆☆☆☆ | 108 M (India) | Stressed Police constables (41 years) | Non-stressed group (67) | PSS score: 35.78 (stressed); 22.42 (non-stressed) | Blood Glucose | – | Higher levels of blood glucose ($p<0.001$)<br>Higher HbA1c ($p<0.001$) |
| Janczura et al. (2015) | Cross-sectional | ☆☆☆ | 235; 216 M, 19 F (Poland) | Police officers (27–58 years) | – | PSS score: 17.5 (MetS+), 15.7 (MetS−) | CV risk factors; Coronary plaque prevalence | – | MetS prevalence $p=0.003$<br>Waist Circumference $p=0.03$<br>Triglycerides ($p=0.002$)<br>BP (syst $p=0.01$, diast $p=0.03$)<br>Coronary plaque prevalence OR 1.05 (95% CI 1.001-1.10) ($p=0.04$) |
| Maia et al. (2008) | Cross-sectional | ☆☆☆☆☆☆ | 118 M (Brazil) | Police officers with PTSD (28 years) | Police officers without PTSD | PTSD checklist Civilian Version | Dyslipidemia | – | PTSD + vs PTSD−<br>Total cholesterol ($p=0.001$)<br>Triglycerides ($p=0.004$) |
| Wright et al. (2011) | Longitudinal (follow-up: 7 years) | ☆☆☆☆☆ | 105 M (USA) | LEOs (42.7 years) | Non LEOs group (65, 48.3 years) | PSS | CV risk factors | – | Regression coefficient (*p* value)<br>DBP ($\beta=0.16$ $p=0.04$)<br>waist circumference ($\beta=0.27$ $p=0.002$) |
| Chen et al. (2015) | Longitudinal (follow-up: 4 years) | ☆☆☆☆☆☆ | 5867 (China) | Police officers: (36.7 years) | – | SCL-90-R GSI = 1.33 (1.13–1.71) | Dyslipidemia | – | HR (95% CI) (*p* value)<br>Dyslipidemia 1.15 (1.05–1.26) ($p=0.004$)<br>High Tot Col: 1.22 (1.08–1.37) ($p=0.001$) |
| Garbarino and Magnavita (2015) | Longitudinal (follow-up: 5 years) | ☆☆☆☆☆ | 235 M (Italy) | Police officers from a flying column (35.4 years) | – | DCS<br>ERI | CV risk factors | Social and demographic factors | aOR (95% CI)<br>MetS: 2.68 (1.08–6.70)<br>Hypertriglyceridemia: 7.86 (1.29–48.04)<br>Reduced HDL: 1.57 (0.40–6.25) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Yu et al. (2016) | Longitudinal (follow-up: 4 years) | ☆☆☆☆☆☆ | 5811 (China) | Police officers 5811 (36.7 years) | – | OSI-R | Type2 Diabetes mellitus | – | RO: HR 1.574 (95% CI 1.071–2.372)<br>RB HR 1.645 (95% CI 1.144–2.365)<br>PE: HR 2.292 (95% CI 1.545–3.400)<br>IS: HR 1.537 (95% CI 1.079–2.191)<br>PHS: HR 1.680 (95% CI 1.167–2.006) |

*aOR* adjusted odds ratio; *BMI* body mass index; *BP* blood pressure; *CV* cardiovascular; *DBP* diastolic blood pressure; *DCS* demand–control–support; *syst* systolic pressure; *diast* diastolic pressure; *ERI* effort–reward imbalance; *HR* hazard ratio; *F* female; *GSI* global severity index; *HbA1c* glycosylated hemoglobin; *HDL* high-density lipoprotein; *High Tot Col* high total cholesterol; *LEOs* law enforcement officers; *M* male; *MetS* metabolic syndrome; *OR* odds ratio; *OSI-R* occupational stress inventory-revised questionnaire; *PSS* perceived stress scale; *PTSD* post-traumatic stress disease; *SCL-90-R* symptom check list-90-revised; *triglyc* triglycerides OSI-R items: *PE* physical environment; *IS* interpersonal strain; *PHS* physical strain; *RB* role boundary; *RO* role overload

**Table 2** Studies concerning the relationship between stress and cardiovascular morbidity

| References | Study design | Study quality | Sample size (location) | Population (mean age or age range) | Controls (mean age) | Exposure (questionnaire) | Outcome | Main results |
|---|---|---|---|---|---|---|---|---|
| Franke et al. (2002) | Cross-sectional | ☆☆ | 2818 M (USA) | Sworn police officers (37.3 years) | General population (8046; 41.7 years) | PSS | CVD | Stress contributed to CVD morbidity OR 1.05 (95% CI 1–1.10) ($p<0.05$) |
| Ramey (2003) | Cross-sectional | ☆☆ | 2818 M (USA) | Sworn police officers (37.3 years) | General population (9650, 45.3 years) | PSS | CVD | Stress contributed to CVD morbidity OR 1.05 (95% CI 1–1.10) ($p<0.05$) |
| Ramey et al. (2011) | Cross-sectional | ☆☆ | 336, 272 M, 42 F (USA) | Urban police officers (41.2 years) | – | PSS; VE | CVD morbidity | OR (95% CI) ($p$ value) Perceived stress 1.20 (1.03–1.39) ($p<0.05$) VE: 1.31 (1.12–1.53) ($p<0.01$) |
| Ramey et al. (2012) | Cross-sectional | ☆☆☆ | 71, 75% M, 25% F (USA) | Police officers (42.2 years)_ | – | PSS, JCQ, ERI, IES, aggression questionnaire | Inflammatory mediators | A unit increase of job demand is associated with an average 3% increase of TNF-α, and 88% increase in IL-1β A unit increase in effort is associated with an average 5% increase of TNF-α |
| Franke et al. (2010) | Cross-sectional | ☆☆ | 444; 322 M, 22 F (USA) | Police officers (37.4 years) | Industrial workers, firefighters (166, 132 M, 34 F, 42 years) | PSS, VE; ERI; social support | Inflammatory mediators | Less than 4% of the variance in any of the inflammatory mediators was explained by any of the stress measures |

*CVD* cardiovascular diseases; *ERI* effort–reward imbalance; *F* female; *JCQ* job content questionnaire; *IES* impact of events scale; *IL-1β* interleukin 1-beta; *M* male; *OR* odds ratio; *PSS* perceived stress scale; *TNF-α* tumor necrosis factor alpha; *VE* vital exhaustion