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Metabolic Syndrome Prevalence among Armed Forces Personnel (Military Personnel and Police Officers): A Systematic Review and Meta-Analysis

Hosein Rostami; Hamid Reza Tavakoli*; Mohammad Hossein Rahimi*†; Mohammad Mohammadi‡§*

ABSTRACT Introduction: Metabolic syndrome (MetS) is closely linked to type 2 diabetes and cardiovascular disease. Various studies have reported the prevalence of MetS in different armed forces personnel in different countries. However, performing a systematic review and meta-analysis on this subject seems necessary. The aim of this study was to estimate the pooled prevalence of MetS among armed forces personnel including members of the military and police forces. Materials and Methods: A systematic review was carried out on all associated papers published in PubMed, Scopus, Web of Science and Cochrane Library, encompassing the timeframe: November, 2018 to January 2000. The overall prevalence of MetS, and its prevalence based on different diagnostic criteria [National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III), American Heart Association (AHA) and International Diabetes Federation (IDF)] were pooled using a random-effects model. Results: Twenty five eligible studies were selected for the meta-analysis. Among all police officers contained in this study group, the overall prevalence of MetS was 26.2% (95% CI: 19.7–34%; Q = 229.45, $p = 0.00$). Among different military personnel contained in this study group, the overall estimation of MetS prevalence was 8.3% (95% CI: 6.3–11%; Q = 540.88, $p = 0.00$) the prevalence of MetS was 8.0% (95% CI: 5.7–11%; Q = 409.76, $p = 0.00$) according to the NCEP-ATP III criterion. Conclusion: The findings from the present meta-analyses displayed a low prevalence of metabolic syndrome in armed forces in general. These findings will allow healthcare providers and policy-makers to find solutions in order to take action to reduce MetS risks on a wider scale, especially among police officers.

INTRODUCTION

Metabolic syndrome (MetS) includes a cluster of risk factors that increase the risk of cardiovascular disease (CVD), type 2 diabetes, and ultimately increased cardiovascular mortality in individuals.[1] Abdominal obesity, dyslipidemia, high blood cholesterol, high serum triglycerides, high blood pressure, insulin resistance (high insulin, oral glucose intolerance), and type 2 diabetes are risk factors for metabolic syndrome. The presence of 3 or more of the above 5 anthropological and biochemical abnormalities is clinically suggestive of MetS.[2] MetS is also associated with other risk factors including: socio-demographic (e.g., low educational attainment, low household income, older age),[3] health behaviors (e.g., physical inactivity, smoking) and neuropsychiatric outcomes (e.g., depression, anxiety and stress). MetS is a collection of metabolic disorders that are more likely to occur together to an individual, rather than separately. Studies have shown that there is a co-incidence in the occurrence of unique metabolic risk factors between individuals, and that the co-existence of multiple risk factors are more harmful than each one occurring alone. The syndrome has attracted the attention of many researchers, due to its associations with diabetes and CVD, and because of its high prevalence among populations. According to the Framingham study, metabolic syndrome alone predicts about 25% of all new cases of CVD.[4]

Armed forces in different countries include two general components – the military and law enforcement. The prevalence of MetS is increasing worldwide, and the armed forces are no exception. The armed forces are an occupational and national institution requiring military service members to exhibit both self-sacrifice and a willingness to serve their countries. Meeting these service obligations gives both risks (such as exposure to negative health behavior norms e.g., cigarette smoking, potential repeated exposure to combat-related stress, injuries from physical training[5,6]) and benefits (such as increased fitness resulting from specialized training and compulsory physical activity[7]). MetS prevention primarily involves diet and exercise programs. During active duty military service, armed forces members are encouraged to establish healthy lifestyle choices, including exercise and diet.[8] Job-related stress sources within the 25 occupation differ between military service members, since they are likely to experience different events as stressful, depending on their individual background, years on the job, personalities, military service experience, type of military work they perform, and access to coping resources.

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In the various military force settings, certain occupational characteristics, such as ergonomic problems, long work hours and, in some jobs, social isolation (training, deployments, other), can have a negative influence on the health status of individuals. The combination of those situations seems to contribute to negative lifestyle changes in these personnel.[9,10] However, many other elements such as dietary factors, atypical work hours,[11] reduced sleep duration,[12] lack of physical activity, or a combination of all these factors play a causative role in negative lifestyle changes in police. It is worth speculating that the occupational factors highlighted might also influence the development of clinical conditions related to greater cardiovascular risks, such as MetS. The main objective of the study was to improve the knowledge and understanding of living conditions and prevalence of MetS among the various military and police forces in different countries.

METHODS

The present study is a systematic review and meta-analysis, and was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Statement.[13]

Search Strategy

The findings of this study were derived from studies conducted worldwide from inception to November 2018, and were from published articles in Medline, Scopus, Cochrane Library, and Google Scholar. All cross-sectional studies of the prevalence of metabolic syndrome, regardless of date or location, were investigated. The search strategy was mainly based on systematic searches combining the terms "Metabolic Syndrome", "prevalence", "military personnel" and "police personnel". All included study reference lists were manually searched to ensure comprehensive coverage.

Eligibility Criteria

The main criterion for including various articles in this study was an estimation of the "prevalence of metabolic syndrome among armed forces". Cross-sectional studies that used any defined criteria to determine MetS prevalence among armed forces were included. Studies that were not part of the primary research, or in the field of treatment, studies non-related to MetS prevalence, reviews and letters to the editors, and study populations containing individuals who were reported to have other health complications were excluded. All articles related to metabolic syndrome prevalence in the armed forces were collected and, after the completion of the search, a list of abstracts was prepared. Subsequently, articles whose samples were based on the established criteria were approved. Preliminary screening was conducted by reading titles and abstracts, and final eligibility was assessed by retrieving the full text of the paper. The process of selecting articles is presented in Fig. 1. Finally, 25 papers[11,14–38] were selected for the meta-analysis phase and the full text of the articles was evaluated for the final analysis.

Data Collection Process

To reduce bias, two authors independently searched, selected articles and extracted information from the chosen articles. A data extraction template of the information needed for all eligible studies, including the name of the researcher, year of publication, country where the study was conducted, sample size, study design, mean age, gender, methods to assess metabolic syndrome, and main results were prepared for the final analysis. In addition, when articles had incomplete data, at least two e-mails were sent to corresponding authors.

Study Grouping based on Occupation

We chose military and police forces for meta-analysis because common psychological and physical abilities of the officers and personnel are necessary for safe performance in such occupations, like being able to handle emotional peak load, being able to hold wakefulness combined with the ability to judge, being able to provide an energetic peak load, having adequate hearing, having good vision and not having too many risk factors for cardiovascular diseases.[39] These abilities are necessary to fulfill the job tasks safely. But, due to some differences in occupation and in standards of living and physical fitness in different armed forces, we divided them into two groups of police officers and military personnel. Police officers include police and law enforcement and military personnel including army, navy and air forces. Among 25 studies, 16 paper were conducted on military personnel[15,16,18–21,23–25,28,30,33–37] and 9 paper were conducted on police officers.[11,14,17,22,26,29,31,32,38] We analyzed the MetS prevalence of both occupational groups (police officers' separately from other military personnel) due to differences in risk factors including: (1) different standards of living, (2) occupational risk factors such as occupational stressors,[40] sudden physical stressors,[41] shift work[42] and sleep problems.[43] These risk factors are not typically seen in military personnel because of personal and military discipline, but it's prevalent among police officers.[39,44] Some studies have identified occupational stressors and reduced cortisol response to a high-protein meal challenge, that may be associated with MetS.[22,45] Also depression, one of the major consequences of stress, is associated with MetS in police officers.[32] As regards the reasons of MetS in police officers, one of the most important is psychological trauma connected with witnessing or facing violence.[46]

Definition of Metabolic Syndrome

The most common definitions are the Third Adult Treatment Panel (ATPIII) of the National Cholesterol Education Program (NCEP) and the International Diabetes Federation (IDF) definitions. The NCEP-ATPIII definition of MetS is defined as the presence of three or more of the following

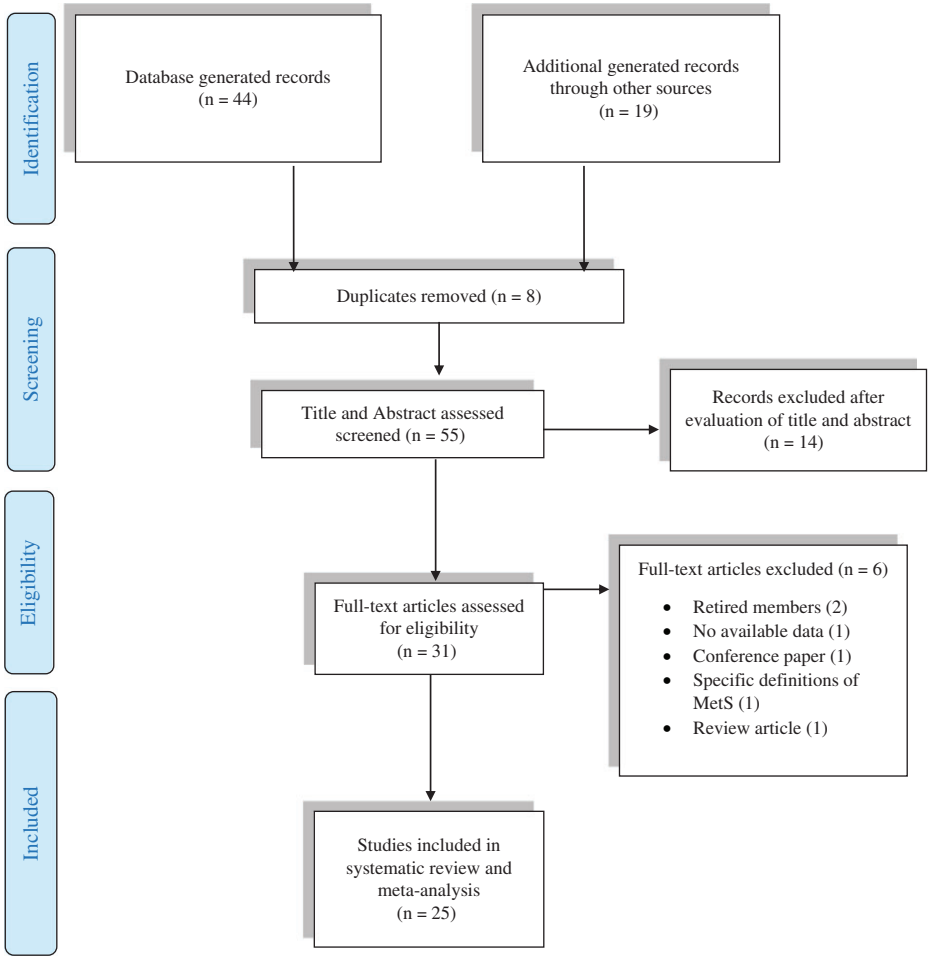

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram of study selection process.

five factors: central obesity (waist circumference > 102 cm for men, > 88 cm for women), raised triglycerides (≥150 mg/dL), raised fasting glucose (≥110 mg/dL), raised blood pressure (BP ≥ 130 mmHg/BP ≥ 85 mmHg), and reduced HDL cholesterol (< 40 mg/dL for men, < 50 mg/dL for women).[47]

The IDF definition is based on the following factors: waist circumference ≥94 cm for men, and ≥80 cm for women; triglycerides ≥150 mg/dL; systolic BP ≥ 130 mmHg or diastolic BP ≥ 85 mmHg; fasting glucose ≥100 mg/dL; and HDL < 40 mg/dL for men, < 50 mg/dL for women. For a diagnosis of MetS using the IDF definition, central obesity must be present.[48]

The AHA definition is based on the NCEP-ATPIII guidelines with recent modifications from the American Heart Association and the National Heart, Lung, and Blood Institute (AHA). The individual MetS components included the following: central obesity (waist circumference > 102 cm for men, > 88 cm for women), raised triglycerides (≥150 mg/dL), raised fasting glucose (≥100 mg/dL), raised blood pressure (BP ≥ 130 mmHg/BP ≥ 85 mmHg), and reduced HDL cholesterol (< 40 mg/dL for men, < 50 mg/dL for women).[49]

Quality Assessment

Quality assessments of the chosen studies were carried out according to the Newcastle-Ottawa scale (NOS).[50] Two authors independently assessed the quality of selected articles using the following criteria: selection (five points for selection of study groups), comparability (two points for comparability of groups), and outcome (three points for ascertainment of outcomes). A star rating system was used to indicate the quality of a study, with a maximum of ten stars. Based on the NOS, the possible maximum and minimum scores for the included studies were 10 stars and 1 star, respectively (Supplemental material 1).

Data and Statistical Analysis

The primary objective for the present study was to evaluate the overall prevalence of MetS among members of the Armed Forces. Therefore, the total sample size for each study as well as the number of people with MetS in each study were used to calculate the prevalence rates and their corresponding 95% confidence intervals (CIs). The pooled prevalence with 95% CI was derived using the random

effects model. Heterogeneity among studies was measured using Cochran's Q test and I-squared statistic. Asymmetry tests including Egger's regression asymmetry test and Begg's adjusted rank correlation were used to examine potential publication bias. Sensitivity analysis was applied by removing the included studies one by one from the meta-analysis to examine if the overall effects depend on a specific study. The P-values of < 0.05 were considered statistically significant. The analyses were conducted with Comprehensive Meta-Analysis (version 2.2.064) software.

RESULTS

Findings from the Systematic Review

In total, 63 articles were identified. Altogether, 8 articles were eliminated due to duplication. After applying the exclusion criteria, 14 articles were eliminated. Altogether, 31 articles were reviewed in full-text, and only 25 articles matched the inclusion criteria and were selected for the present meta-analysis (Fig. 1).

Based on the quality assessment of the included studies with regard to the sample selection, almost all of the studies used an acceptable sampling method, but some failed to report the truly representative average of the target population and a justified and satisfactory sample size. Most studies controlled for confounders, such as demographic factors, and most of the studies also used validated instruments to determine MetS.

Among the 25 studies conducted between 2005 and 2018, there were 12 articles in Asia (7 in the Middle East),[15–17,23,24,26,28,30,31,33–35] 5 in Europe,[18,20,22,36,37] 7 in America (5 in USA)[11,14,19,21,27,29,32] and 1 in Australia.[25] 7 articles were conducted on military personnel in the army,[18,20,23,33–36,51] 4 on air force officers,[16,24,25,30] 9 on police officers,[11,14,17,22,26,27,29,31,32] 3 on soldiers,[15,21] 1 on navy[19] and 1 on parachutists[28] (Table I). Among military personnel and police officers, the sample sizes were 18818 and 4090, respectively.

The prevalence of MetS in articles was reported based on different criteria and was also compared:

in 9 studies among police officers, the prevalence of MetS in 6 studies was calculated based on the NCEP-ATP III criteria, in which the highest prevalence was in the 2014 Filho et al. study (35%) on 451 Brazilian police officers with a mean age of 45.8,[14] while the lowest prevalence was in Garbarino et al.'s 2015 article (11.5%) on 234 police officers with a mean age of 41 in Italy.[22] In the one study where MetS was calculated based on IDF, Tharkar et al. reported high prevalence on 318 police officers in India in 2008 (57.3%).[31] In the 3 studies where MetS was calculated based on AHA, Hartley et al. reported the highest prevalence on 130 police officers in the Spokane Heart Study (SHS) in 2011 (36.9%),[32] whereas Chang reported the lowest prevalence (24.5%) on 796 police officers in Taiwan in 2015[17] (Table I). The total sample sizes of studies using the criteria of NCEP-ATP III, IDF and AHA were 2436, 318, and 1336, respectively. The results showed that studies using IDF criteria presented the highest prevalence, and NCEP-ATP III criteria reported the lowest prevalence, and that differences in the prevalence of MetS among armed forces varied by ~45.8%.

In 16 studies among military personnel, the prevalence of MetS in 14 studies was calculated based on the NCEP-ATP III criteria, in which the highest prevalence was in the 2005 Al-Qahtani et al. study (52%) on 1079 Saudi military personnel with a mean age of 36.15,[15] while the lowest prevalence was in Lee et al.'s 2018 article (0.8%) on 4083 military personnel with a mean age of 20.8 in Korea.[35] In the 4 studies where MetS was calculated based on IDF, Costa et al. reported the highest prevalence on 1383 military navy personnel in Brazil in 2011 (17.9%) (19), while Maleki et al. reported the lowest prevalence (4.4%) on 1,000 air force guards in Iran in 2016.[16] The total sample sizes of studies using the criteria of NCEP-ATP III and IDF were 16389 and 3525, respectively, without any study on the basis of AHA. Also, it should be considered that among studies, 2 of them, reported MetS prevalence on the basis of both ATP and IDF[16,28] (Table I).

Findings from the Meta-Analysis

The overall prevalence of MetS was estimated from pooled information from 16 selected studies among military personnel and 9 among police officers, separately. However, in studies among military personnel two subgroups were allocated based on different criteria: the NCEP-ATP III subgroup contained 14 studies and 4 studies were classified in the IDF subgroup. It was interesting to observe that in 12 studies, participants were male and in and in two other studies, the proportion of men was higher than women. Also, one subgroup was allocated based on age where the studies were conducted in 14 studies using the NCEP-ATP III criterion. Due to insufficient number of studies on police officers, subgroup was not performed.

Among all police officers, the overall prevalence of MetS was 26.2% (95% CI: 19.7–34%; Q = 229.45, $p = 0.00$) according to the NCEP-ATP III, IDF and AHA definition. Figure 2 shows the pooled estimations of MetS overall prevalence, using random effect meta-analysis of the data extracted from various studies.

Among different military personnel, the overall estimation of MetS was 8.3% (95% CI: 6.3–11%; Q = 540.88, $p = 0.00$) in military personnel (Fig. 3) and the prevalence of MetS was 8.0% (95% CI: 5.7–11%; Q = 409.76, $p = 0.00$) according to the NCEP-ATP III criterion and 9.6% (95% CI: 4.7–18.8%; Q = 111.94, $p = 0.002$) based on the IDF definition. Supplemental material 2 and 3 show the pooled estimations of MetS prevalence according to NCEP-ATP III and IDF criteria, respectively, using random effect meta-analysis of the data extracted from various studies.

MetS prevalence in age groups ≥ 30 and < 30 years of age was 13.9% (95% CI: 1–19.1%; Q = 49.5, $p = 0.00$) and 4.2%

TABLE I. Characteristics of the Included Studies

Author	Country	Year	Design	Armed force type	MetS criteria	Gender	Average age (years)	Total sample	MetS percent
Lee	Korea	2018	cross-sectional	military personnel	NCEP-ATP III	M	20.8	4,803	0.8
Payab	Iran	2017	cross-sectional	military personnel	NCEP-ATP III	M	37.33	2,200	11
Cranston	USA	2017	cross-sectional	air force retirees	AHA	M & F	48.2	381	37.2
Maleki	Iran	2016	cross-sectional	air guard forces	NCEP-ATP III and IDF *	M	~	1,000	3.2
Janak	USA	2016	cross-sectional	military service #	NCEP-ATP III	M	52	887	11.3
Sharma	Australia	2016	cross-sectional	military aircrew	NCEP-ATP III	M & F	~	210	11.9
Chang	Taiwan	2015	cross-sectional	police officers	AHA	M	37.3	796	24.5
Garbarino	Italy	2015	cross-sectional	police officers	NCEP-ATP III	M	41	234	11.5
Rhee	Korea	2015	cross-sectional	military aviators	NCEP-ATP III	M	~	911	9.8
Filho	Brazil	2014	cross-sectional	police officers	NCEP-ATP III	M	45.8	451	35
Wirth	USA	2014	cross-sectional	police officers	NCEP-ATP III	M & F	42.4	444	28
Thayyil	India	2012	cross-sectional	police officers	NCEP-ATP III	M	41	823	16
Khoshdel	Iran	2012	cross-sectional	parachutists @	NCEP-ATP III and IDF *	M	37.4	96	5.2
Costa	Brazil	2011	cross-sectional	military navy	IDF	M	~	1,383	17.9
Hartley (Buffalo study)	USA	2011	cross-sectional	police officers	AHA	M & F	~	410	25.6
Hartley (Spokane)	USA	2011	cross-sectional	police officers	AHA	M & F	~	130	36.9
Ying-lu	China	2011	cross-sectional	military retired residences	CMA	M & F	77	4,502	35.2
Violanti	USA	2010	cross-sectional	police officers	NCEP-ATP III	M & F	39.5	98	16.3
Hagnas	Finland	2012	cross-sectional	military service #	IDF	M	~	1,046	7
Heydari	Iran	2010	cross-sectional	military personnel	NCEP-ATP III	M	35.1	337	8.2
Iravani	Iran	2010	cross-sectional	military personnel	NCEP-ATP III	M	35	365	8.1
Tharkar	India	2008	cross-sectional	police officers	IDF	M	44.3	318	57.3
Ceppa	France	2008	cross-sectional	military personnel	NCEP-ATP III	M	38.6	2,045	9
Yoo	USA	2007	cross-sectional	law enforcement officers ¥	NCEP-ATP III	M & F	39.1	386	23
Nawaf	Jordan	2007	cross-sectional	air force pilots	NCEP-ATP III	M	32.5	111	15
Al-Qahtani	Saudi Arabia	2005	cross-sectional	Soldiers #	NCEP-ATP III	M	36.15	1,079	18.6
Bauduceau	France	2005	cross-sectional	military personnel	NCEP-ATP III	M	40	2,045	9
Athyros	Greece	2004	cross-sectional	military personnel	NCEP-ATP III	M & F	37	300	9.4

NCEP-ATP III = National Cholesterol Education Program's Adult Panel III; IDF = International Diabetes Federation; AHA = American Heart Association; CMA = Chinese Medical Association; M = male; F = female.

~ Not reported.

* Percentage of prevalence have been reported on basis of ATPIII in the table.

Coded in the meta-analysis as military personnel.

@ Coded in the meta-analysis as air force officers.

¥ Coded in the meta-analysis as police officers.

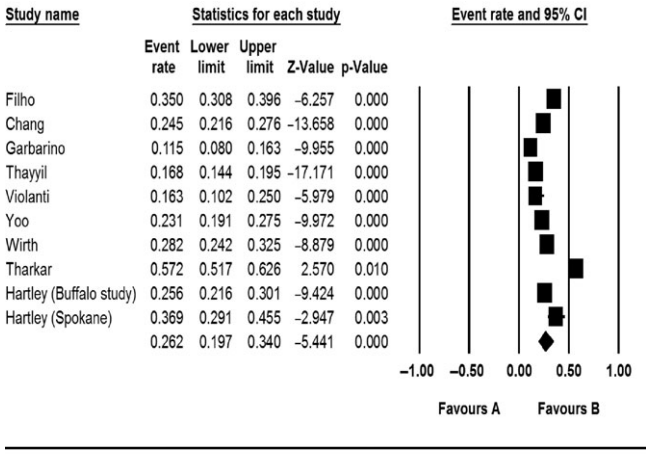

FIGURE 2. Forest plot: pooled estimations of MetS overall prevalence among police officers.

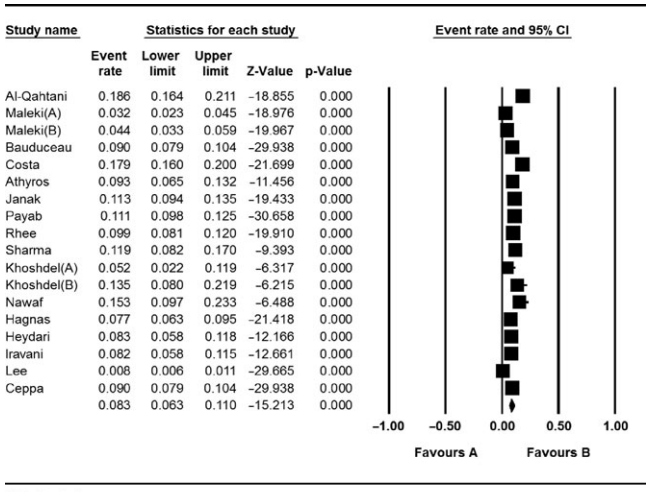

FIGURE 3. Forest plot: pooled estimations of MetS overall prevalence among military personnel.

(95% CI: 1.5–10.7%; Q = 144.59, $p = 0.00$), respectively, according to the NCEP-ATP III criterion (Supplemental material 4). MetS prevalence higher than the normal value was more common for older individuals (13.9% versus 4.2%).

Publication Bias

The Begg test and Egger's test indicated there was no strong evidence for publication bias in the overall estimation of MetS in 9 studies among police officers ($p = 0.81$ and $p = 0.34$) and 16 studies among military personnel ($p = 0.41$ and $p = 0.21$). (Supplemental material 5 and 6).

Sensitivity Analysis

Sensitivity analysis indicated that no study had a significant impact on the overall effect sizes of MetS prevalence among police officers and military personnel.

DISCUSSION

General Findings

To the authors' knowledge, this is the first meta-analysis of MetS prevalence in armed forces personnel. Several studies have reported the prevalence of MetS representing different armed forces, population characteristics, background, location, etc. As a result, studies have shown a high range of variability in MetS prevalence. This variation could be affected by the different diagnostic criteria for MetS, age, and occupation, or even by the sampling design used. Differences in the criteria of MetS definition were observed in the definition of MetS in the method section. For example, the estimated prevalence of MetS in armed forces personnel was reported to vary from as low as 0.8% to as high as 57% or even higher, depending on the armed forces type and the criteria of the MetS definition used. In parachutists, the MetS prevalence was found to be 5.2% according to ATP III, and 13.5% according to IDF.[28] Therefore, it seems that some of the differences in the reported prevalence levels were due to the differential diagnostic criteria for MetS.

The current meta-analysis demonstrates that particular military occupations may have a pivotal role when considering metabolic abnormalities in individuals.

In 9 studies on police officers, the highest MetS prevalence was related to studies conducted among them.[14,29,31,32] Previous research has also demonstrated that police officers are at an increased risk for MetS. If the data from studies on police officers are added together, metabolic syndrome affects approximately 26.2% of policemen. These results suggest that the prevalence of metabolic syndrome in policemen is below the national average of most countries, but that occupation-related stressors are associated with important cardiovascular risk factors. This is inconvenient, since police personnel are often expected to be in good shape and to be able to perform their professional activities with agility and physical strength.

Also, this study showed that individuals in military forces had the lowest MetS prevalence in some studies[16,25,28,35,36] conducted among military personnel. This low prevalence compared to that of the general population could probably be explained on the basis of military personnel lifestyles, including their relatively higher standard of living and high level of physical activity. Prevention of MetS first and foremost involves diet and exercise programs. For example, during active duty military service, U.S. Air Force (USAF) members are encouraged to establish healthy lifestyle choices, including diet and exercise, and their fitness program assesses both exercise capacity and body composition of active duty members every 6 months. Furthermore, to ensure military mission readiness, the yearly Periodic Health Assessment targets CVD risk factors by encouraging physical activity, a healthy diet, and periodically measuring lipid profiles and blood pressure.[52] Members who do not make enough progress toward the minimum standards usually receive administrative separation from the military.[52] In the

analysis of military branches, the air force branch had lower prevalence of MetS among armored groups, however, the prevalence of MetS in military units overall is lower than that of other armed forces such as police officers. In addition to lifestyle, there are other factors contributing to the low prevalence of MetS in the military. When young men are initially recruited, all of them undergo physical checkups, and those individuals with underlying medical conditions including body mass index (BMI) higher than 30 are either exempted from military service or are placed in public service instead.[35,53] Therefore, some military personnel included in the current study may have better health status relative to police officers or the general population.

Strengths and Limitations

The strength of the present study is that it is the first study which shows the prevalence of MetS in armed forces personnel. This meta-analysis may provide baseline data, and can guide other researchers to design new studies. Also, one threat to the validity of any meta-analysis is due to heterogeneity and publication bias. There was no strong evidence for publication bias, but heterogeneity was encountered in all analyses, despite creating subgroups for different diagnostic criteria of MetS, age, and geographical location. While this is the first comprehensive and thorough meta-analysis of MetS in people with military occupations conducted to date, several limitations are acknowledged, which are reflected by factors in the data in addition to the reported heterogeneity. First, there were insufficient available data to conduct separate analyses in terms of evaluating all age groups. Another limitation was the lack of information about lifestyle and nutrition of the participants, which could explain part of the observed high prevalence in police officers.

CONCLUSION

In conclusion, this meta-analysis clearly shows that MetS has a low prevalence among the armed forces, except for police officers (26%). The high prevalence of MetS in police officers should be seriously considered by the Institutes for Occupational Safety and Health for interventions that reduce and prevent unhealthy weight gain that may be a good investment of resources and should be studied further. Also future studies investigating the prevalence of MetS and its components among armed forces populations would benefit from using a universally-accepted diagnostic tool for MetS, that does not yet exist and further studies should use different methods such as the NCEP-ATPIII, IDF, AHA and WHO definitions that have significant differences. This would enable prevalence estimates to be monitored and compared to each other.

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