Prevalence of metabolic syndrome in active military personnel: an updated systematic review and meta-analysis

M. U. Ibadova[1], M. G. Mukhamedova[1], Z. A. Pulatova[1]

Military Medical Institute of the University of Military Security and Defense of the Republic of Uzbekistan

Published 27 September 2026 | DOI: 10.14419/j.jtumed.2026.09.27

Abstract

Objective. To estimate the pooled prevalence of metabolic syndrome (MetS) in active military personnel and to identify the sources of between-study heterogeneity.

Materials and methods. PubMed was searched on 4 October 2026 without date or language limits, and the studies included in a previous meta-analysis were checked. Studies reporting the prevalence of MetS, defined by recognised or explicitly stated criteria, in active armed-forces personnel were eligible; police officers, veterans and clinical samples were excluded. Proportions were pooled after logit transformation with a DerSimonian–Laird random-effects model, heterogeneity was explored with subgroup analyses and meta-regression, and study quality was appraised with the JBI checklist for prevalence studies.

Results. Sixteen studies with 27,351 participants from 13 countries were included; 3,254 participants had MetS. The pooled prevalence was 11.8% (95% CI 9.1–15.1), with a 95% prediction interval of 3.8–31.1% and $I^2 = 97.9\%$. Prevalence was higher in studies using the International Diabetes Federation definition (18.4%) than in those using three of five criteria (9.7%; $p = 0.001$) and higher in aircrew (22.1%) than in other personnel (10.1%), and it was lowest in conscripts, young enlisted soldiers and cadets (1.5% vs 16.0% in other, mainly career, personnel). In the nine studies that reported it, mean age explained 49% of the between-study variance ($p < 0.001$).

Conclusion. About one in eight active service members has MetS, but the prevalence varies with the definition used, age structure and type of service. Military surveillance programmes should apply one harmonised definition, report age-specific estimates and give priority to career personnel, older servicemen and aircrew for early detection and prevention.

Keywords: *metabolic syndrome; military personnel; prevalence; meta-analysis; abdominal obesity; aircrew*

Introduction

Metabolic syndrome (MetS) is a cluster of abdominal obesity, atherogenic dyslipidaemia, raised blood pressure and dysglycaemia. It is diagnosed by the criteria of the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) and their 2005 revision [1, 2], by the International Diabetes Federation (IDF) definition, in which central obesity is obligatory [3, 4], or by the harmonised Joint Interim Statement (JIS), in which any three of five abnormal findings qualify [4]. MetS is associated with a higher risk of cardiovascular disease (relative risk 2.35) and of cardiovascular death [5, 6], of type 2 diabetes [7] and of chronic kidney disease [8]. In the general adult population, its global prevalence ranges from 12.5% to 31.4% depending on the definition [9].

Military personnel are selected for health and fitness, but their cardiometabolic profile is changing. In the United States active duty population, overweight and obesity increased from 50.6% in 1995 to 60.8% in 2008 [10], obesity increased from 14.7% to 24.2% between 2013 and 2023 [11], and the incidence of type 2 diabetes rose from 55.5 to 69.6 per 100,000 person-years between 2018 and 2021 [12]. Night-shift work, night sentry duty and post-traumatic stress disorder have been associated with MetS or its components [13–15], so the burden of MetS in service members is directly relevant to fitness for duty and to the planning of preventive medical examinations.

Two previous meta-analyses gave conflicting estimates: 8.3% for military personnel, pooled separately from police officers [16], and 21% for ten studies using the ATP III criteria in a review that also included police officers [17]. Several large studies have been published since then. The aim of this study was to update the pooled prevalence of MetS in active military personnel, restricted to recognised or explicitly stated definitions, and to examine the definition, region, type of service and age as sources of heterogeneity.

Materials and methods

Protocol and search

The review followed the PRISMA 2020 statement [18], the MOOSE recommendations for meta-analyses of observational studies [19] and the JBI guidance for systematic reviews of prevalence data [20]. The protocol, including the eligibility criteria, search strategy and data items, was written before screening but was not registered; the statistical analyses were not specified in it. PubMed (MEDLINE) was searched on 4 October 2026 from inception, without language restrictions, with the query ("metabolic syndrome"[tiab] OR "Metabolic Syndrome"[MeSH Terms]) AND ("Military Personnel"[MeSH Terms] OR military OR soldier OR soldiers OR army OR "armed forces" OR navy OR naval OR "air force" OR servicemen OR "service members" OR "active duty" OR conscripts OR recruits, all in title or abstract). The 37 studies included in the most recent previous meta-analysis [17] were also checked against the search results; the list of studies of the earlier review [16] could not be obtained.

Eligibility, selection and data extraction

Cross-sectional studies and baseline data of cohorts were eligible if they reported the number or percentage of participants with MetS and the denominator in active personnel of national armed forces, including aircrew, submariners, conscripts and cadets of military academies, and if MetS was defined by NCEP ATP III or its revisions, IDF, JIS or another explicitly stated set of criteria; one study that did not name its definition but reported MetS as three or more of five listed components was included and omitted in a sensitivity analysis. Police officers, veterans and retirees, civilian employees, samples selected for a disease or risk factor, and studies identifying MetS only from diagnostic codes, not stating how MetS was defined or reporting only age-standardised prevalence were excluded. Titles and abstracts were screened by two reviewers, each assessing half of the records; full texts were assessed when available and abstracts otherwise, and uncertain records were decided by a senior reviewer. Data were extracted with a standard form, and a second reviewer verified every extracted data value against the source. When only a percentage was reported, the number of cases was taken as the nearest integer to the percentage multiplied by the denominator and was accepted if it reproduced the published percentage within 0.1 percentage point (within rounding for percentages given as whole numbers). When several definitions were reported, the estimate based on three of five criteria was used in the main analysis and the IDF estimate in a sensitivity analysis; for cohorts described in several reports, the report with the largest sample was used. Quality was appraised by one reviewer with the nine-item JBI checklist for prevalence studies [20, 21]; items not reported were rated unclear, and no study was excluded because of quality.

Statistical analysis

Proportions were logit-transformed and pooled with the DerSimonian–Laird random-effects model [22]; the 95% confidence intervals (CI) of individual studies were calculated by the Wilson score method [23]. Heterogeneity was quantified with Cochran's Q, I^2 and τ^2 [24, 25], and a 95% prediction interval was calculated for the prevalence expected in a new study [26, 27]. Subgroup analyses compared the definition, region (the Americas, Europe, Asia, and Africa and the Middle East), type of service, publication period, sample size, sex composition and data source (full text or abstract only), with a random-effects test of subgroup differences. Random-effects meta-regression [28] was performed for mean age and publication year. Small-study effects were assessed with Egger's test on the logit scale [29]. Sensitivity analyses used the restricted maximum likelihood estimator of τ^2 [30], the Freeman–Tukey double arcsine transformation, interpreted with caution [31], the IDF estimates where available, and the omission of derived counts, of conscripts and cadets, of the study with an unnamed definition, of studies with fewer than 300 participants and of each study in turn. The analyses were performed in Python 3 (NumPy, SciPy) with code checked against the statsmodels implementation; $p < 0.05$ was considered significant.

Results

Study selection and characteristics

The search returned 226 records, and the previous meta-analysis added 25 reports not retrieved by the search, none of them eligible (no MetS data, n = 21; civilian seafarers or mariners, n = 4). Of the 251 records, 182 were excluded on the title and abstract and 69 reports were assessed for eligibility. Of these, 32 were excluded, most often because the crude prevalence of MetS was not reported (n = 14) or the definition was not specified or was non-standard (n = 9); 21 reports described cohorts already included. Sixteen studies were included (Figure 1).

The 16 studies were published between 2005 and 2026 and included 27,351 participants (range 53–7,504) from Brazil (three studies), Taiwan (two) and one study each from Colombia, the United States, France, Finland, Greece, Serbia, Jordan, Tunisia, Ghana, South Korea and Thailand (Table 1). Three studies examined aircrew, two naval personnel and three conscripts, young enlisted soldiers or cadets; six were restricted to men. MetS was defined by NCEP ATP III or its revisions in eight studies, by an unnamed rule of three of five criteria in one, by JIS in three and by IDF in four; all definitions other than IDF required any three abnormal criteria.

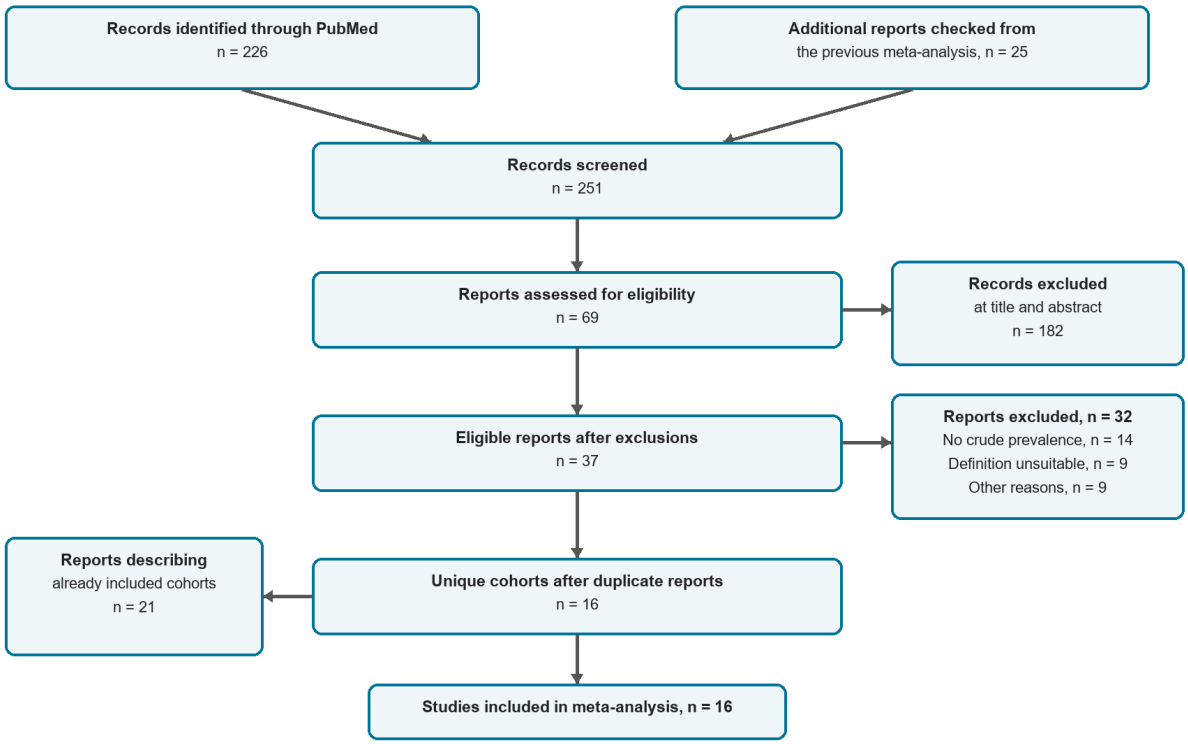


Figure 1. Flow diagram of study selection (PRISMA 2020)

MetS, metabolic syndrome.

Table 1. Characteristics of the included studies

Study	Country	Population	N	Men, %	Mean age, years	Definition	MetS, n	MetS, %
Athyros 2005 [32]	Greece	Military personnel (comparison group of a national survey)	300	—	—	ATP III	28a,c	9.3
Bauduceau 2005 [33]	France	Military personnel, Paris region (EPIMIL)	2,045	100	—	ATP III	185	9.0
Khazale 2007 [34]	Jordan	Air force pilots	111	—	32.5	ATP III	17	15.3
Mikkola 2007 [35]	Finland	Conscripts	1,099	100	≈19	ATP III	38a	3.5
Nillakupt 2010 [36]	Thailand	Military medical cadets	96	81.3	—	ATP III, modified	1a	1.0
Costa 2011 [37]	Brazil	Navy personnel	1,383	100	—	IDF	243a	17.6
Radjen 2011 [38]	Serbia	Military pilots	179	—	39.7	IDF	51	28.5
Gasier 2016 [39]	USA	Submarine crew	53	100	29	ATP III, revisedd	10a	18.9
Chen 2018 [40]	Taiwan	Military personnel, eastern Taiwan (CHIEF)	7,504	89.8	29	ATP III, Asian waist	1,021a	13.6
Lee 2018 [41]	South Korea	Army corporals	4,803	—	20.8	ATP III, revised	40	0.8
Fortes 2019 [42]	Brazil	Army peacekeeping contingents	2,719	100	27.8	JIS	332	12.2
Allani 2021 [43]	Tunisia	Garrison personnel	2,500	96.7	36.6	IDF	443a	17.7
da Rosa 2021 [44]	Brazil	Army personnel	270	100	37.5	JIS	74	27.4
Chang 2023 [45]	Taiwan	Army volunteer soldiers	1,720	85.0	—	JISb	246	14.3
Malpica 2023 [46]	Colombia	Air force aircrew and air traffic controllers	2,179	—	—	3 of 5, not named	473a	21.7
Ayeltigah 2026 [47]	Ghana	Personnel nominated for deployment	390	76.4	—	IDF	52	13.3

Note. a Number calculated from the published percentage and sample size (halves rounded up). b Labelled IDF by the authors but defined as any three of five criteria with waist ≥90/80 cm. c Published as 9.4%; no integer count out of 300 reproduces it exactly (possibly age-standardised); active-duty status not stated. d Systolic and diastolic blood pressure counted as separate criteria. ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Federation; JIS, Joint Interim Statement; MetS, metabolic syndrome; —, not reported.

Pooled prevalence

MetS was present in 3,254 of 27,351 participants. The prevalence in individual studies ranged from 0.8% in young Korean army corporals [41] to 28.5% in Serbian military pilots [38]. The pooled prevalence was 11.8% (95% CI 9.1–15.1), and heterogeneity was very high (I^2 = 97.9%, τ^2 = 0.30, Q = 708.2, $p < 0.001$); the 95% prediction interval of 3.8–31.1% shows the range of prevalence expected in a new military population (Figure 2).

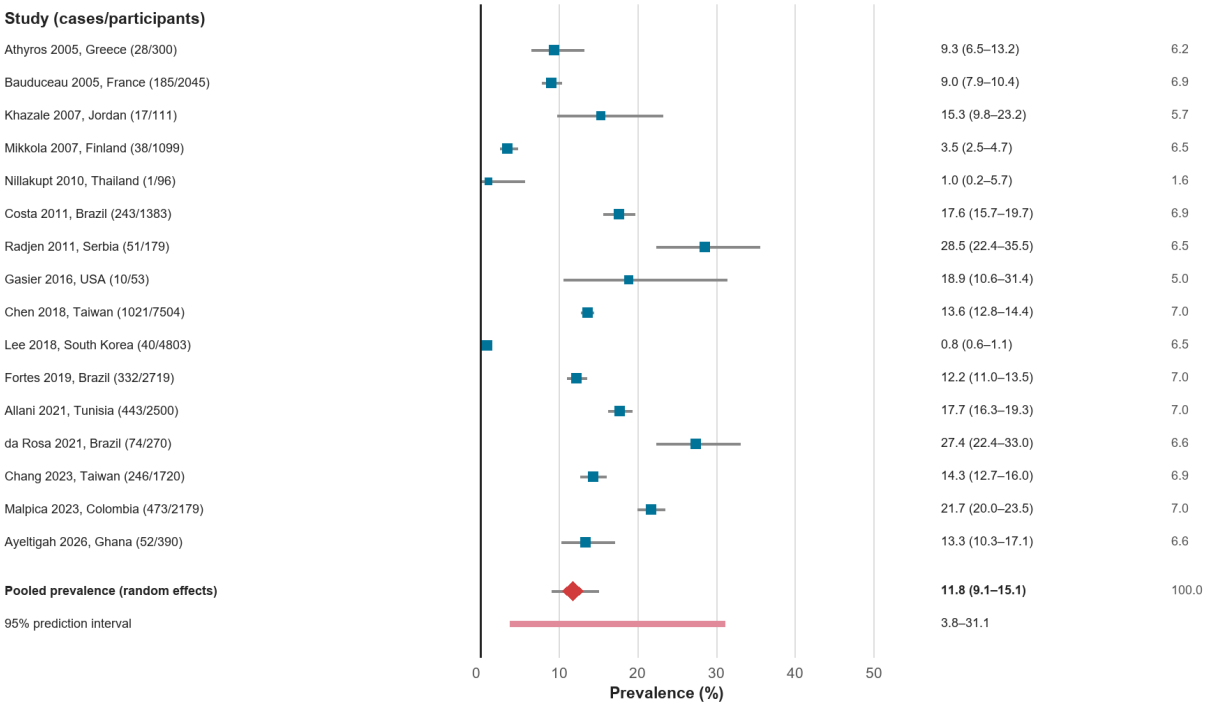


Figure 2. Forest plot of the prevalence of metabolic syndrome in active military personnel

Dark marks, study estimates (mark width proportional to the weight); light bars, 95% CI (Wilson); red, pooled random-effects estimate (DerSimonian–Laird, logit transformation) with the dashed reference line; pink, 95% prediction interval. MetS, metabolic syndrome.

Sources of heterogeneity

The prevalence differed by definition ($p = 0.004$): it was 7.7% with ATP III criteria or the unnamed three-of-five rule, 16.8% with JIS and 18.4% with IDF (Figure 3); all three-of-five definitions combined gave 9.7%, compared with 18.4% with IDF ($p = 0.001$). Because ATP III and JIS both require three of five criteria, the split between them followed the authors' labels, except that one study labelled IDF but applying any three of five criteria was classed as JIS and the unnamed rule was grouped with ATP III; the comparison of IDF with all three-of-five definitions does not depend on this split. The prevalence also differed by region ($p = 0.015$), being highest in the Americas (18.9%) and lowest in Asia (4.6%), and by type of service: aircrew had a higher prevalence than other personnel (22.1% vs 10.1%; $p < 0.001$), and conscripts, young enlisted soldiers and cadets had a much lower prevalence than other, mainly career, personnel (1.5% vs 16.0%; $p < 0.001$). The three studies of conscripts and cadets all used ATP III criteria, so the effects of definition and age cannot be separated. The prevalence did not differ by publication period ($p = 0.54$), sex composition ($p = 0.69$) or data source ($p = 0.97$), and the difference by sample size was not significant ($p = 0.071$).

In meta-regression, mean age (reported in 9 studies) explained 49% of the between-study variance: each additional year was associated with 16% higher odds of MetS (slope 0.149 on the logit scale, 95% CI 0.100 to 0.198; $p < 0.001$), corresponding to a predicted prevalence of 2.7% at a mean age of 20 years and 35.0% at 40 years (Figure 4). Publication year was not associated with prevalence (slope 0.031 per year, $p = 0.13$).

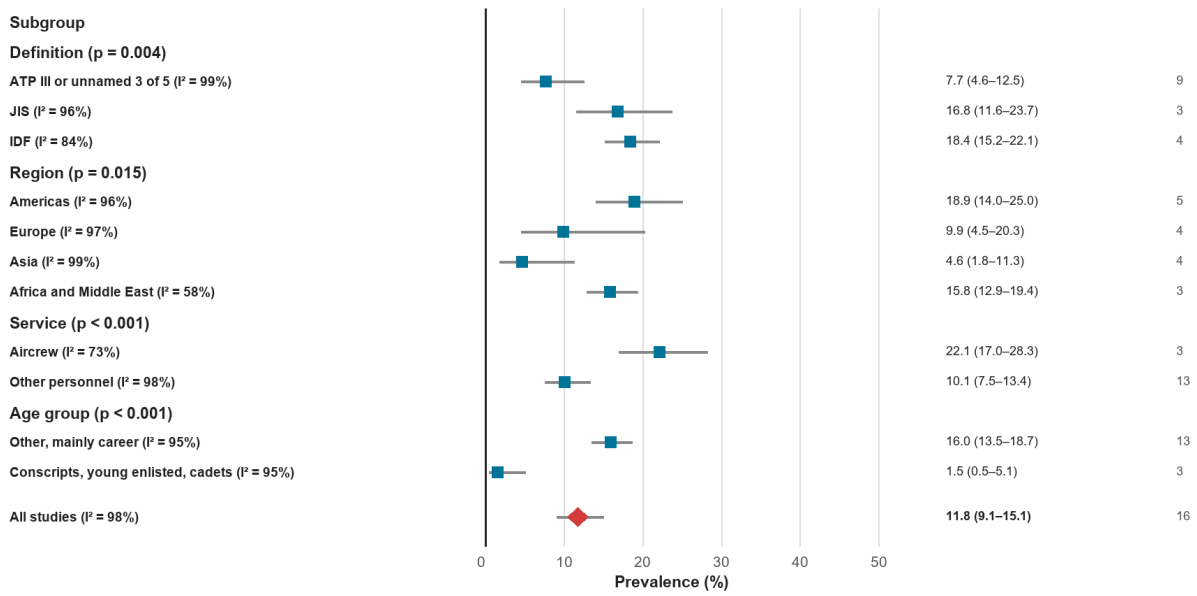


Figure 3. Pooled prevalence of metabolic syndrome in subgroups

Orange, subgroup random-effects estimates with 95% CI; red, all studies. p, random-effects test of subgroup differences. ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Federation; JIS, Joint Interim Statement.

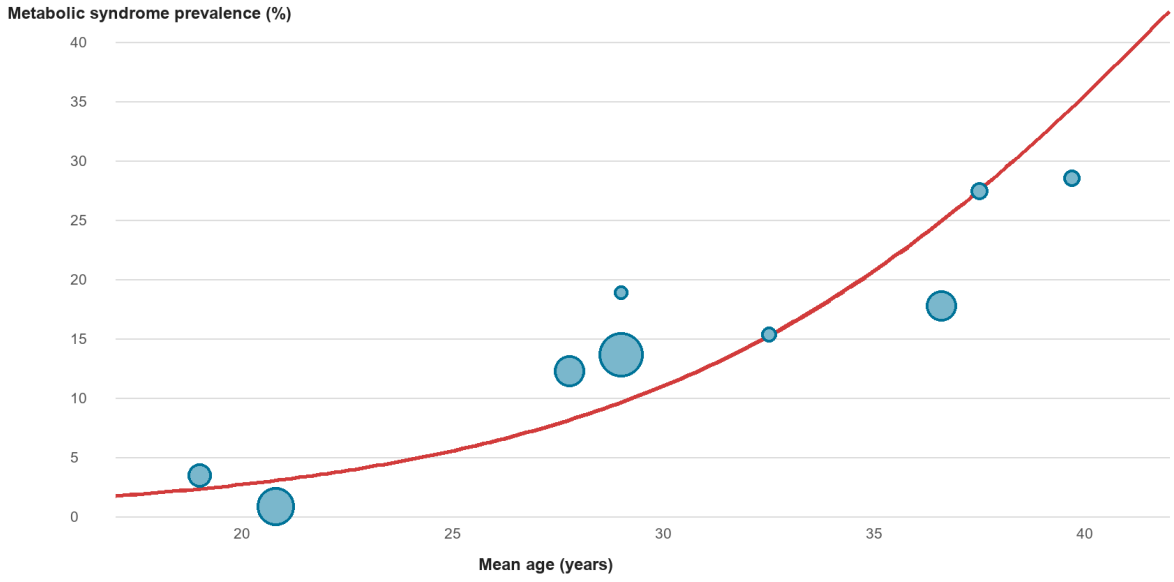


Figure 4. Meta-regression of the prevalence of metabolic syndrome on the mean age of participants

Bubble area is proportional to the sample size (53–7,504). Red line, random-effects meta-regression (logit scale, back-transformed). MetS, metabolic syndrome.

Components, quality and sensitivity analyses

All five components were reported in four studies (Figure 5). Abdominal obesity was the most frequent component in two of them (49.5% in Tunisia and 46.2% in Colombia) and high blood pressure in the other two (69.7% in Ghana and 21.5% in Korea); the least frequent were high triglycerides in Ghana (5.4%), high blood pressure in Tunisia (11.9%) and high fasting glucose in Colombia (12.5%) and Korea (1.7%). On the JBI checklist, an adequate response rate could be confirmed in only 1 study and appropriate sampling in 4, whereas valid identification of MetS was confirmed in 15 of 16 studies (Figure 6).

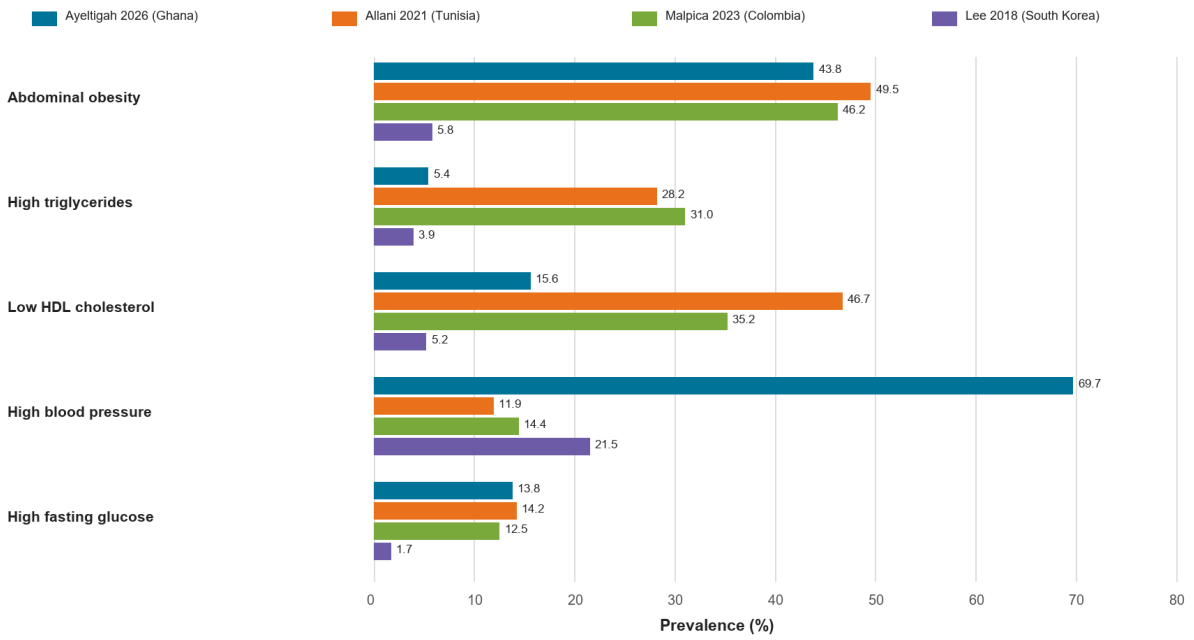


Figure 5. Prevalence of the components of metabolic syndrome in the studies that reported all five

Component definitions follow each study (IDF in Ghana and Tunisia, three of five criteria in Colombia, revised ATP III with Asian waist cut-off in Korea).

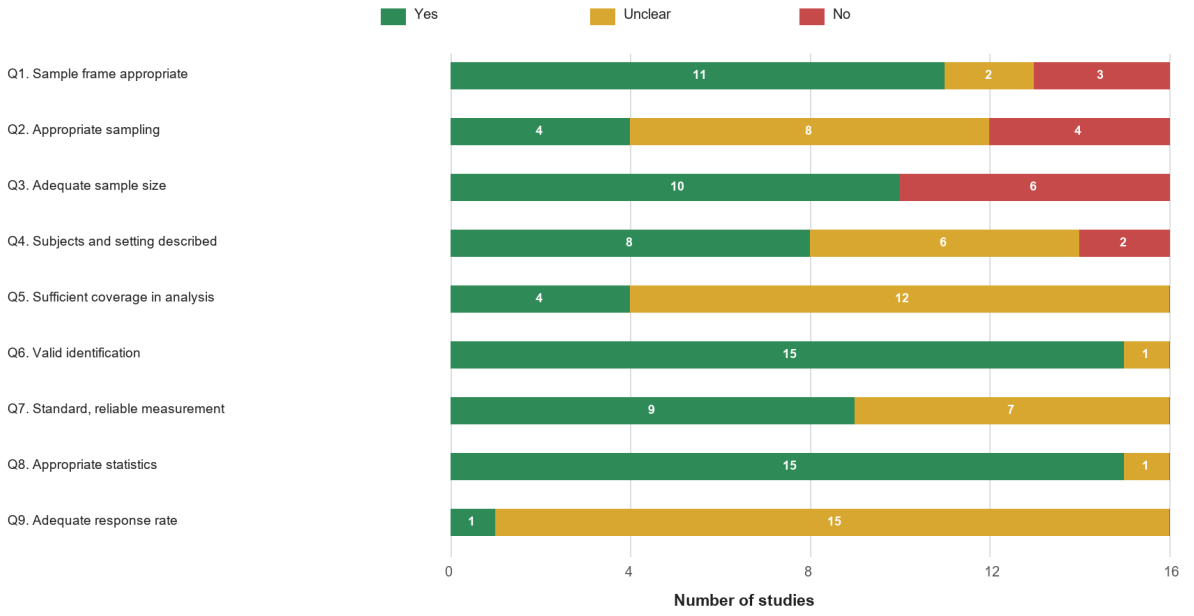


Figure 6. Methodological quality of the included studies (JBI checklist for prevalence studies)

Numbers in the bars are numbers of studies.

The point estimate was similar with the restricted maximum likelihood estimator (11.3% (95% CI 7.1–17.5)), although this estimator gave a larger τ2 (1.01 vs 0.30) and a wider prediction interval (1.4–54.1%), and with the double arcsine transformation (12.6% (95% CI 8.4–17.5)); it was also similar with IDF estimates where both were reported (12.0% (95% CI 9.3–15.5)) and without studies with derived counts (11.5% (95% CI 6.9–18.6)), and omitting each study in turn gave estimates from 11.0% (without Radjen 2011) to 14.1% (without Lee 2018). Excluding the three studies of conscripts and cadets increased the pooled prevalence to 16.0% (95% CI 13.5–18.7) (Table 2). The funnel plot and Egger's test showed no evidence of small-study effects (intercept −3.11, p = 0.32; Figure 7).

Table 2. Sensitivity analyses of the pooled prevalence of metabolic syndrome

Analysis	Studies	Participants	Prevalence, %	95% CI	I2, %
Main analysis (DerSimonian–Laird, logit)	16	27,351	11.8	9.1–15.1	98
Restricted maximum likelihood estimator	16	27,351	11.3	7.1–17.5	98
Freeman–Tukey double arcsine transformation	16	27,351	12.6	8.4–17.5	99
IDF estimate where several definitions were reported	16	27,351	12.0	9.3–15.5	98
Studies with reported counts only	8	12,237	11.5	6.9–18.6	98
Without conscripts, young enlisted soldiers and cadets	13	21,353	16.0	13.5–18.7	95
Without the study with an unnamed definition	15	25,172	11.2	8.5–14.5	98
Studies with at least 300 participants	11	26,642	9.9	7.4–13.2	98
Leave-one-out analysis (range)	15	—	11.0–14.1	—	96–98

Note. For Chen 2018, the IDF count consistent with the published sex-specific percentages (831) was used. CI, confidence interval; IDF, International Diabetes Federation; I2, proportion of total variation due to between-study heterogeneity.

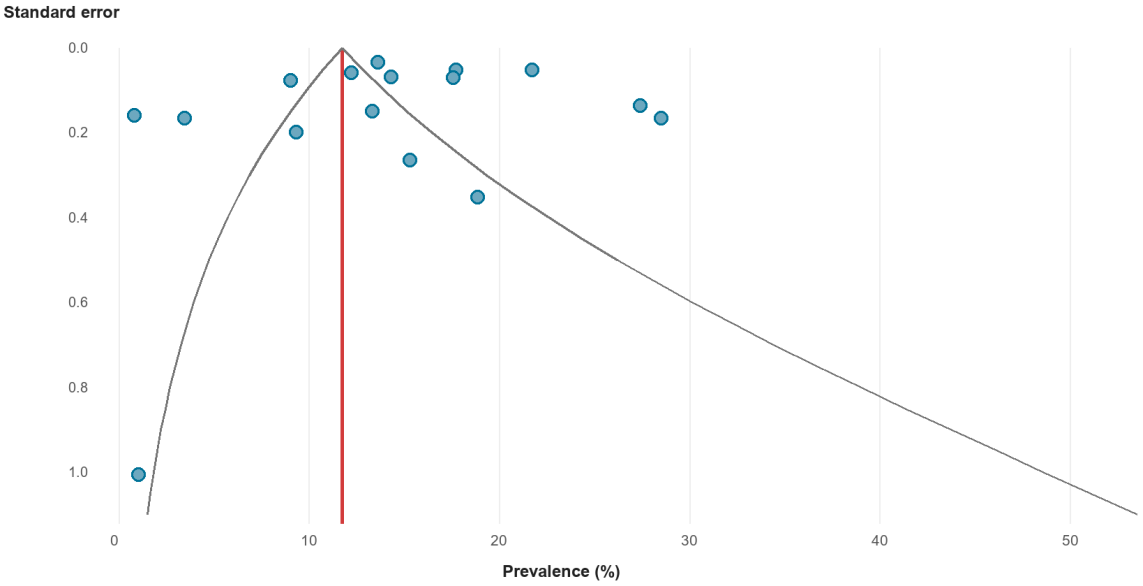


Figure 7. Funnel plot of the prevalence of metabolic syndrome in the included studies

Each circle is a study; dashed lines, pseudo 95% confidence limits around the pooled estimate (logit scale, back-transformed); red line, pooled prevalence. Egger's test: intercept −3.11, p = 0.32. MetS, metabolic syndrome.

Discussion

In this updated meta-analysis of 16 studies including 27,351 active service members from 13 countries, about one in eight had MetS (11.8% (95% CI 9.1–15.1)). The prediction interval of 3.8–31.1% (1.4–54.1% with the restricted maximum likelihood estimator) shows that the prevalence in a new military population may range from very low to one in three or more, so a single pooled figure should not be used without considering the definition, age structure and type of service. The estimate lies between those of the two previous meta-analyses, 8.3% for military personnel [16] and 21% for ten studies using ATP III criteria [17]. The difference from the latter is probably explained partly by our exclusion of police officers and of age-adjusted estimates, both of which entered that review; five of our studies were published after both reviews, although the prevalence was not associated with the publication period.

The pooled prevalence lies at or just below the lower end of the 12.5–31.4% reported for the general adult population [9], although most military samples were younger. In the Korean study, MetS was found in 0.8% of young soldiers compared with 7.9% of young civilian men, and high physical activity was associated with lower odds of MetS (odds ratio 0.19) [41]; in a large United States cohort, prior military service was not associated with MetS (prevalence ratio 0.98) [48]. Health selection at enlistment, regular physical training and the young age of most samples are the most likely explanations. In northern Finland, the prevalence of MetS among conscripts fell from 6.1% to 3.6% during 6–12 months of service and by 40% among obese conscripts [49], which suggests that physical training during service can reverse early metabolic changes.

The prevalence was almost twice as high in studies using the IDF definition as in those using three of five criteria, but this between-study difference is confounded: in the two studies that reported both, the IDF definition gave a higher estimate in one (6.8% vs 3.5%) [35] and a lower one in the other (11.1% vs 13.6%) [40]. The IDF definition requires central obesity but uses lower,

ethnic-specific waist thresholds, whereas the JIS definition has no obligatory component [4]; among Kazakh adults in north-western China, the prevalence varied from 13.8% with ATP III to 24.8% with JIS in the same sample [50]. In our data the definition was partly confounded by age, because all three studies of conscripts and cadets used ATP III criteria. In the nine studies that reported mean age, each additional year of mean age was associated with about 16% higher odds of MetS, a study-level association that agrees with the Royal Thai Army cohort, in which the incidence of MetS in men aged 45 years or older was more than six times that in men younger than 35 years [51]. Aircrew had the highest prevalence; the two aircrew studies that reported age had mean ages of 32.5 and 39.7 years, older than most samples that reported age, whereas in the Colombian study pilots had a lower prevalence (17.7%) than other crew members in that study [46], so flying duties alone are unlikely to explain the difference; the three aircrew studies also used different definitions.

Abdominal obesity and high blood pressure were the leading components. Among young Korean soldiers, high blood pressure was the only component more frequent than in the general population (21.5% vs 18.2%) [41], and in Ghana it affected 69.7% of personnel nominated for deployment [47]. Because obesity among service members is increasing [10, 11], waist circumference and blood pressure should be measured at every periodic examination; the waist-to-height ratio discriminates cardiometabolic risk better than waist circumference or body mass index [52], and current guidelines recommend measuring body mass index and waist circumference at least annually in adults at risk of cardiovascular-kidney-metabolic syndrome [53].

Lifestyle intervention reduced the incidence of MetS by 41% in the Diabetes Prevention Program [54] and doubled the proportion of patients in whom MetS resolved in a meta-analysis of randomised trials [55]; in the Royal Thai Army, regular exercise was associated with a greater one-year decrease in the visceral adiposity index (difference −0.56) [56]. However, weight-loss programmes for active duty personnel have produced modest effects [57], and the evidence for their efficacy remains insufficient [58].

No study from Uzbekistan or other Central Asian armed forces met the inclusion criteria, although MetS and abdominal obesity are common in the region's general population [59, 60] and a high cardiovascular risk was found in 16.8–19.6% (laboratory- and non-laboratory-based estimates) of 1,735 adults aged 40–74 years screened in four regions of Uzbekistan [61]. National data on service members, collected with the JIS criteria and population-specific waist thresholds [4] and reported by age group and type of service, are therefore needed.

The strengths of this review are the restriction to active armed-forces personnel and to recognised or explicitly stated definitions, the verification of every extracted data value by a second reviewer, and the exploration of heterogeneity by subgroup analysis and meta-regression. Its limitations are the search of a single database, the unregistered protocol, in which the analyses were not specified, the reliance on abstracts for eight studies, the use of counts calculated from percentages for eight studies, the appraisal of quality by a single reviewer, the incomplete reporting of age and sampling, and the very high heterogeneity, which makes the pooled estimate an average of different populations rather than a single true value.

Conclusion

MetS affects about 12% of active military personnel, with subgroup estimates ranging from 1.5% in conscripts, young enlisted soldiers and cadets to 22.1% in aircrew. The prevalence was higher in studies of older personnel and almost twice as high in studies using the IDF definition as in those requiring three of five criteria. Military medical services should monitor waist circumference and blood pressure from the start of service, apply one harmonised definition in periodic examinations, and focus preventive programmes on career personnel, older servicemen and aircrew.

References

1. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). JAMA. 2001;285(19):2486-97. doi:10.1001/jama.285.19.2486

2. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation. 2005;112(17):2735-52. doi:10.1161/CIRCULATIONAHA.105.169404

3. Alberti KG, Zimmet P, Shaw J; IDF Epidemiology Task Force Consensus Group. The metabolic syndrome--a new worldwide definition. Lancet. 2005;366(9491):1059-62. doi:10.1016/S0140-6736(05)67402-8

4. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):1640-5. doi:10.1161/CIRCULATIONAHA.109.192644

5. Mottillo S, Filion KB, Genest J, Joseph L, Pilote L, Poirier P, et al. The metabolic syndrome and cardiovascular risk a systematic review and meta-analysis. J Am Coll Cardiol. 2010;56(14):1113-32. doi:10.1016/j.jacc.2010.05.034

6. Gami AS, Witt BJ, Howard DE, Erwin PJ, Gami LA, Somers VK, et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. J Am Coll Cardiol. 2007;49(4):403-14. doi:10.1016/j.jacc.2006.09.032

7. Ford ES. Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care. 2005;28(7):1769-78. doi:10.2337/diacare.28.7.1769

8. Thomas G, Sehgal AR, Kashyap SR, Srinivas TR, Kirwan JP, Navaneethan SD. Metabolic syndrome and kidney disease: a systematic review and meta-analysis. Clin J Am Soc Nephrol. 2011;6(10):2364-73. doi:10.2215/CJN.02180311

9. Noubiap JJ, Nansseu JR, Lontchi-Yimagou E, Nkeck JR, Nyaga UF, Ngouo AT, et al. Geographic distribution of metabolic syndrome and its components in the general adult population: A meta-analysis of global data from 28 million individuals. Diabetes Res Clin Pract. 2022;188:109924. doi:10.1016/j.diabres.2022.109924

10. Reyes-Guzman CM, Bray RM, Forman-Hoffman VL, Williams J. Overweight and obesity trends among active duty military personnel: a 13-year perspective. Am J Prev Med. 2015;48(2):145-53. doi:10.1016/j.amepre.2014.08.033

11. Emmerich SD, Mabila SL, Stierman B, Ogden CL. Trends in the prevalence of obesity among U.S. active component service members and civilians, 2013-2023. MSMR. 2026;32(12):17-24.

12. Stiegmann RA, Payne CB, Kiel MA, Stahlman SL. Increased Prevalence of Overweight and Obesity and Incidence of Prediabetes and Type 2 Diabetes During the COVID-19 Pandemic, Active Component Service Members, U.S. Armed Forces, 2018 to 2021. MSMR. 2023;30(1):11-8.

13. Wang F, Zhang L, Zhang Y, Zhang B, He Y, Xie S, et al. Meta-analysis on night shift work and risk of metabolic syndrome. Obes Rev. 2014;15(9):709-20. doi:10.1111/obr.12194

14. Lin YP, Hsu YC, Lin KH, Tsai KZ, Chu CC, Lin YC, et al. Nocturnal sentry duty and cardiometabolic characteristics in armed forces personnel. World J Cardiol. 2024;16(12):751-9. doi:10.4330/wjc.v16.i12.751

15. Rosenbaum S, Stubbs B, Ward PB, Steel Z, Lederman O, Vancampfort D. The prevalence and risk of metabolic syndrome and its components among people with posttraumatic stress disorder: a systematic review and meta-analysis. Metabolism. 2015;64(8):926-33. doi:10.1016/j.metabol.2015.04.009

16. Rostami H, Tavakoli HR, Rahimi MH, Mohammadi M. Metabolic Syndrome Prevalence among Armed Forces Personnel (Military Personnel and Police Officers): A Systematic Review and Meta-Analysis. Mil Med. 2019;184(9-10):e417-e425. doi:10.1093/milmed/usz144

17. Baygi F, Herttua K, Jensen OC, Djalalinia S, Mahdavi Ghorabi A, Asayesh H, et al. Global prevalence of cardiometabolic risk factors in the military population: a systematic review and meta-analysis. BMC Endocr Disord. 2020;20(1):8. doi:10.1186/s12902-020-0489-6

18. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71

19. Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA. 2000;283(15):2008-12. doi:10.1001/jama.283.15.2008

20. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc. 2015;13(3):147-53. doi:10.1097/XEB.0000000000000054

21. Munn Z, Moola S, Riitano D, Lisy K. The development of a critical appraisal tool for use in systematic reviews addressing questions of prevalence. Int J Health Policy Manag. 2014;3(3):123-8. doi:10.15171/ijhpm.2014.71

22. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986;7(3):177-88. doi:10.1016/0197-2456(86)90046-2

23. Wilson EB. Probable inference, the law of succession, and statistical inference. J Am Stat Assoc. 1927;22(158):209-12. doi:10.1080/01621459.1927.10502953

24. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21(11):1539-58. doi:10.1002/sim.1186

25. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557-60. doi:10.1136/bmj.327.7414.557

26. IntHout J, Ioannidis JP, Rovers MM, Goeman JJ. Plea for routinely presenting prediction intervals in meta-analysis. BMJ Open. 2016;6(7):e010247. doi:10.1136/bmjopen-2015-010247

27. Riley RD, Higgins JP, Deeks JJ. Interpretation of random effects meta-analyses. BMJ. 2011;342:d549. doi:10.1136/bmj.d549

28. Thompson SG, Higgins JP. How should meta-regression analyses be undertaken and interpreted? Stat Med. 2002;21(11):1559-73. doi:10.1002/sim.1187

29. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629-34. doi:10.1136/bmj.315.7109.629

30. Viechtbauer W. Bias and efficiency of meta-analytic variance estimators in the random-effects model. J Educ Behav Stat. 2005;30(3):261-93. doi:10.3102/10769986030003261

31. Schwarzer G, Chemaitelly H, Abu-Raddad LJ, Rücker G. Seriously misleading results using inverse of Freeman-Tukey double arcsine transformation in meta-analysis of single proportions. Res Synth Methods. 2019;10(3):476-83. doi:10.1002/jrsm.1348

32. Athyros VG, Bouloukos VI, Pehlivanidis AN, Papageorgiou AA, Dionysopoulou SG, Symeonidis AN, et al. The prevalence of the metabolic syndrome in Greece: the MetS-Greece Multicentre Study. Diabetes Obes Metab. 2005;7(4):397-405. doi:10.1111/j.1463-1326.2004.00409.x

33. Bauduceau B, Baigts F, Bordier L, Burnat P, Ceppa F, Dumenil V, et al. Epidemiology of the metabolic syndrome in 2045 French military personnel (EPIMIL study). Diabetes Metab. 2005;31(4 Pt 1):353-9. doi:10.1016/s1262-3636(07)70204-5

34. Khazale NS, Haddad F. Prevalence and characteristics of metabolic syndrome in 111 Royal Jordanian Air Force pilots. Aviat Space Environ Med. 2007;78(10):968-72. doi:10.3357/asem.2097.2007

35. Mikkola I, Keinänen-Kiukaanniemi S, Laakso M, Jokelainen J, Härkönen P, Meyer-Rochow VB, et al. Metabolic syndrome in connection with BMI in young Finnish male adults. Diabetes Res Clin Pract. 2007;76(3):404-9. doi:10.1016/j.diabres.2006.09.019

36. Nillakupt K, Viravathana N. A survey of metabolic syndrome and its components in Thai medical cadets. J Med Assoc Thai. 2010;93 Suppl 6:S179-85.

37. Costa FF, Montenegro VB, Lopes TJ, Costa EC. Combination of risk factors for metabolic syndrome in the military personnel of the Brazilian Navy. Arq Bras Cardiol. 2011;97(6):485-92. doi:10.1590/s0066-782x2011005000113

38. Radjen SD, Jovelic AS, Radjen GS, Hajdukovic ZV, Radakovic SS. Metabolic syndrome and carotid artery intima-media thickness in military pilots. Aviat Space Environ Med. 2011;82(6):622-6. doi:10.3357/asem.2981.2011

39. Gasier HG, Young CR, Gaffney-Stomberg E, McAdams DC, Lutz LJ, McClung JP. Cardiometabolic Health in Submariners Returning from a 3-Month Patrol. Nutrients. 2016;8(2):85. doi:10.3390/nu8020085

40. Chen KW, Meng FC, Shih YL, Su FY, Lin YP, Lin F, et al. Sex-Specific Association between Metabolic Abnormalities and Elevated Alanine Aminotransferase Levels in a Military Cohort: The CHIEF Study. Int J Environ Res Public Health. 2018;15(3):545. doi:10.3390/ijerph15030545

41. Lee JH, Seo DH, Nam MJ, Lee GH, Yang DH, Lee MJ, et al. The Prevalence of Obesity and Metabolic Syndrome in the Korean Military Compared with the General Population. J Korean Med Sci. 2018;33(25):e172. doi:10.3346/jkms.2018.33.e172

42. Fortes MSR, Rosa SED, Coutinho W, Neves EB. Epidemiological study of metabolic syndrome in Brazilian soldiers. Arch Endocrinol Metab. 2019;63(4):345-50. doi:10.20945/2359-3997000000115

43. Allani R, Amiri N, Ammar H, Dhaouadi S, Horrigue I, Khoufi MT, et al. Determinants of metabolic syndrome: a population survey at Bizerte military garrison in 2015-2017. Tunis Med. 2021;99(6):662-8.

44. da Rosa SE, Costa AC, Fortes MSR, Marson RA, Neves EB, Rodrigues LC, et al. Cut-Off Points of Visceral Adipose Tissue Associated with Metabolic Syndrome in Military Men. Healthcare (Basel). 2021;9(7):886. doi:10.3390/healthcare9070886

45. Chang CF, Wu YC, Lai CH, Chen PC, Guo YL. Effects of physical fitness training on metabolic syndrome among military personnel in Taiwan. BMJ Mil Health. 2023;169(e1):e15-e19. doi:10.1136/bmjmilitary-2020-001761

46. Malpica D. Metabolic Syndrome, Hyperlipidemias, and Associated Clinical Markers Among Military Airmen. Aerosp Med Hum Perform. 2023;94(8):604-9. doi:10.3357/AMHP.6242.2023

47. Ayeltigah D, Taabazuing B, Amoako M, Gyamfi A, Ayensu J. Work stress, dietary patterns and metabolic syndrome among military personnel in Ghana: a cross-sectional study. BMJ Open. 2026;16(8):e109662. doi:10.1136/bmjopen-2025-109662

48. Janak JC, Pérez A, Alamgir H, Orman JA, Cooper SP, Shuval K, et al. U.S. military service and the prevalence of metabolic syndrome: Findings from a cross-sectional analysis of the Cooper Center Longitudinal Study, 1979-2013. Prev Med. 2017;95:52-8. doi:10.1016/j.ypmed.2016.11.017

49. Hagnäs MP, Cederberg H, Mikkola I, Ikäheimo TM, Jokelainen J, Laakso M, et al. Reduction in metabolic syndrome among obese young men is associated with exercise-induced body composition changes during military service. Diabetes Res Clin Pract. 2012;98(2):312-9. doi:10.1016/j.diabres.2012.09.009

50. Guo H, Liu J, Zhang J, Ma R, Ding Y, Zhang M, et al. The Prevalence of Metabolic Syndrome Using Three Different Diagnostic Criteria among Low Earning Nomadic Kazakhs in the Far Northwest of China: New Cut-Off Points of Waist Circumference to Diagnose MetS and Its Implications. PLoS One. 2016;11(2):e0148976. doi:10.1371/journal.pone.0148976

51. Sakboonyarat B, Rangsin R, Mittleman MA. Incidence and risk factors of metabolic syndrome among Royal Thai Army personnel. Sci Rep. 2022;12(1):15692. doi:10.1038/s41598-022-19024-8

52. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev. 2012;13(3):275-86. doi:10.1111/j.1467-789X.2011.00952.x

53. Ndumele CE, Rodriguez F, Dixon DL, Khan SS, Mukherjee D, Bajaj M, et al. 2026 AHA/ACC/ADA/ASN Guideline for the Prevention, Detection, Evaluation, and Management of Cardiovascular-Kidney-Metabolic Syndrome: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. J Am Coll Cardiol. 2026;87(22S):e1889-e2007. doi:10.1016/j.jacc.2026.03.056

54. Orchard TJ, Temprosa M, Goldberg R, Haffner S, Ratner R, Marcovina S, et al. The effect of metformin and intensive lifestyle intervention on the metabolic syndrome: the Diabetes Prevention Program randomized trial. Ann Intern Med. 2005;142(8):611-9. doi:10.7326/0003-4819-142-8-200504190-00009

55. Yamaoka K, Tango T. Effects of lifestyle modification on metabolic syndrome: a systematic review and meta-analysis. BMC Med. 2012;10:138. doi:10.1186/1741-7015-10-138

56. Sakboonyarat B, Poovieng J, Wongkliawrian N, Jongcherdchootrakul K, Srisawat P, Mungthin M, et al. Effect of exercise on decreasing Visceral Adiposity Index among the Royal Thai Army personnel in Thailand: a 1-year follow-up study. BMJ Mil Health. 2025 Jul 31:military-2025-003009. doi:10.1136/military-2025-003009. Epub ahead of print.

57. Krukowski RA, Hare ME, Talcott GW, Gladney LA, Johnson KC, Richey PA, et al. Dissemination of the Look AHEAD Intensive Lifestyle Intervention in the United States Military: A Randomized Controlled Trial. Obesity (Silver Spring). 2018;26(10):1558-65. doi:10.1002/oby.22293

58. Csizmar GT, Irwin M. Efficacy of Weight Loss Interventions in United States Active Duty Military Populations: A Systematic Review. Mil Med. 2021;186(11-12):1093-9. doi:10.1093/milmed/usab012

59. Sadykova A, Shalkharova ZS, Shalkharova ZN, Sadykova K, Madenbay K, Zhunissova M, et al. Metabolic syndrome and its components in southern Kazakhstan: a cross-sectional study. Int Health. 2018;10(4):268-76. doi:10.1093/inthealth/ihy027

60. Polupanov AG, Khalmatov A, Altymysheva A, Lunegova OS, Mirrakhimov AE, Sabirov IS, et al. The prevalence of major cardiovascular risk factors in a rural population of the Chui region of Kyrgyzstan: The results of an epidemiological study. Anatol J Cardiol. 2020;24(3):183-91. doi:10.14744/AnatolJCardiol.2020.59133

61. Odilov K, Chimed-Ochir O, Yumiya Y, Murayama H, Fukunaga A, Yoshida T, et al. Analysis of adult non-communicable disease (NCD) screening data in Uzbekistan using the UZ-SPEED NCD tool. Public Health. 2026;254:106217. doi:10.1016/j.puhe.2026.106217