PREVALENCE OF DIETARY SUPPLEMENT USE AMONG THE MILITARY POPULATION: A SYSTEMATIC REVIEW AND META-ANALYSIS

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SUMMARY

Objectives: The aim of the study was to evaluate widespread dietary supplements (DSs) use among the military population. There is no recent study to comprehensively evaluate the prevalence of DS use among the military population. Therefore, this systematic review and meta-analysis aimed to present an overview and estimate of the overall prevalence of DSs use among the military population.

Methods: PubMed, Scopus, Web of Science, and Google Scholar databases were searched up to September 2023 using relevant keywords. All original articles written in English evaluating the prevalence of DSs use among the military population were eligible for this study. The risk of bias assessment of the included studies was done using the Joanna Briggs Institute critical appraisal checklist. The meta-analysis was performed utilizing a random-effects model and STATA software.

Results: In total, 32 cross-sectional studies were included in this review. The prevalence rate of DS use in the overall military population was 57% (95% CI: 49–64); this rate was higher in the studies that were carried out in the USA and the studies with a sample size lower than 10,000 members. Eleven studies reported adverse effects (AEs) following DSs use in the military population, the pooled effect size of them was 13.0% (95% CI: 6–20). The most common AEs reported by military personnel were abdominal pain, nausea, vomiting, and diarrhoea, however, they did not include any serious complications.

Conclusion: The findings indicate that the prevalence of DSs use among the military personnel was high. Moreover, some studies reported AEs following DSs use such as gastrointestinal symptoms. Promotion of knowledge and informed attitudes regarding the DSs use in the military population could be useful.

Key words: dietary supplement, adverse effect, military, systematic review, meta-analysis

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https://doi.org/10.21101/cejph.a8321

INTRODUCTION

Dietary supplements (DS) are compounds added to one's diet to attain benefits in health and daily functions (1), among which are vitamins, amino acids, minerals, and herbs (2). These bioactive substances are commonly used in different populations (3). More than half of adults in different countries use DSs regularly (4–8), with people in military occupations using them more often than the general population (9–12). Most soldiers consume DSs regularly, and an increasing trend in DS usage is evident (13). The use of DS among athletes has also consistently been reported to be high depending on the type of sport and level of competition (14, 15).

People often use DSs to make up for their inadequate nutrition and improve their health (16), some may also seek to augment their performance, both mentally and physically (17). Soldiers use DSs to enhance health, increase muscle strength, and gain energy (18), with use to augment performance also rising (9). These factors explain why athletes (19) and military staff (20) might more commonly use DSs than the general population. Some soldiers undertake intense and prolonged physical activity in extreme environments, which can increase their required energy and nutrients. A survey in Slovenia (21) revealed that while meals were prepared in line with nutritional recommendations, some military personnel failed to consume the required amount of food to meet dietary targets (22).

The rise in DS use is alarming in light of their adverse effects (AEs) and insufficient evidence of their efficacy (23, 24). Determining the incidence of AEs related to DS can assist in establishing the safety of these supplements. Such AEs include insomnia (23), liver damage (24), an increased risk of bleeding (23), interactions with ibuprofen (25), and death (26). AEs occur most commonly in the gastrointestinal, nervous and cardiovascular systems (27). While there have been numerous reports of AEs concerning DSs among military staff (28, 29) and civilians (30, 31), it is not easy to establish causality in some cases of self-reported AEs (32). AE incidence was especially high among

users of combination products and purported prohormone supplements (31). It is reported that AEs tended to occur with products marketed for weight loss (27).

The previous review by Knapik et al. (17) reported the prevalence of DSs use by military subjects but, numerous investigations have studied the prevalence of various DSs use and their AEs among the military population since then. Moreover, to our best knowledge, there is no recent study to systematically evaluate the prevalence of DS use among the military population. Hence, we conducted a systematic review and meta-analysis to summarize the evidence of the prevalence of DS use among military personnel.

MATERIALS AND METHODS

Search Strategy

All steps of this study were conducted considering the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (supplementary S Table 1). The protocol of this study has also been registered in the International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42024506496. Electronic databases of Scopus, Web of Science, Google Scholar, and PubMed were searched by the MeSH terms and the following keywords (supplementary S Table 2):

"Supplement or supplementation or multivitamin or vitamin or mineral or sports drink or nutraceutical or neutraceutical" AND "military or soldier or sailor or airmen or marine armed force or coast guard or submariners or Navy or air force".

The search was limited to September 2023. Moreover, a manual search of the references list of eligible studies and Google was conducted to minimize the risk of lost relevant papers. The similar articles section in the PubMed database and the studies that cited the included studies were also screened to find all eligible studies. The articles were downloaded to the Endnote software (Version X20) to manage citations.

Eligibility Criteria

The retrieved articles were systematically screened and all English language original literature that addressed the prevalence of DSs use in military personnel was included in this review. In the current review, the observational studies including cross-sectional and cohort studies that evaluated the prevalence of the DSs use among the military population were eligible for this review. DSs are vitamins, amino acids, minerals, and herbs that were defined previously (2). The definition of the search keywords and the screening of the included articles was done according to the PICO criteria, which for the present review included the prevalence studies, was defined as CoCoPop, which includes the Condition of study (DSs use), the Context of study (around the world), and the Population of study (military population). The studies that reported the prevalence of a single specific body-building or another single specific DSs were not included in the present review. Review articles, book chapters, theses, letters, posters, conference publications, editorials, case reports, case series, and commentary were not included. Randomized clinical trials that studied the effects of specific supplementation on health outcomes in the military population and articles that evaluated the prevalence of energy drinks among these populations were excluded from this study. Studies with full-text not available were also excluded.

Selection of the Studies and Data Extraction

After removing duplicate articles, the achieved articles were independently screened by two authors according to the eligibility criteria. First, the titles and abstracts of the included studies were evaluated by the eligibility criteria. Then, the full text of eligible studies was further evaluated, and articles that did not meet the predefined criteria or contained insufficient information were excluded. If there was any disagreement, it was resolved by consensus with the third author. Data extraction was also done by two independent authors who retrieved the required data using a standard extraction table. The items in the extraction table were considered by consensus with the third author. Moreover, the required data for conducting meta-analysis was entered into Microsoft Excel. The extracted data of the included studies were the authors' name, publication year, study design and location, sample size, population type and sex, type of used DSs, method for data collection, prevalence of used DSs, and AFs of DSs use.

Assessment of the Studies' Risk of Bias

Two independent authors used the Joanna Briggs Institute critical appraisal checklist (33) for studies reporting prevalence data assessing the quality, methodology, and risk of bias of the included studies. The questions of the tool are shown in supplementary S Table 3. The results were evaluated and if any disagreement existed between the two reviewers, the third author assessed the study.

Data Analysis

In this systematic review and meta-analysis study, we used random effects models through the restricted maximum likelihood method to calculate the prevalence rates of DSs consumption and 95% CIs. To detect heterogeneity, we used the I^2 statistic and Cochrane's Q test, and the I^2 value > 50% or $p < 0.1$ for the Q test was finally considered as significant heterogeneity among the studies. Subgroup analysis was done based on the sample size, the country, the data collection method, the type of used dietary supplement, and the year of publication of the studies. Egger's and Begg's formal tests and visual inspection of funnel plots were used to examine the publication bias. The p-value is less than 0.05 as the significance of the findings. STATA software version 17.0 was used to perform all statistical analyses (Stata Corporation, College Station, TX, USA).

RESULTS

Selection of Studies

In the initial search, 25,851 records were retrieved from the electronic search databases including Web of Science (n = 1,169), Scopus (n = 10,601), PubMed (n = 4,188), and Google Scholar (n = 310). After removing duplicates, 21,630 articles remained

Table 1. *Characteristics of the studies on the prevalence and adverse effects of dietary supplement use among the military population*

Reference	Country/study design	Population/sex	Sample size and age of participants	Supplement type	Methods for data collection	Prevalence of supplement use	Adverse effects
Knapik et al. 2023 (58)	USA/cross-sectional	Military services members/ M and F	26,680/> 18 years	MVM, IVM, proteins/AA, herbal products	Questionnaire	75.37% used any supplement	–
Sammito et al. 2022 (59)	Germany/cross-sectional	Wing commanders/M and F	178/24–59 years	Protein supplements, magnesium, omega-3 fatty acids	Online survey	34% used any supplement: protein supplements (33%), magnesium (22%), omega-3 fatty acids (20%)	–
Knapik et al. 2022 A (32)	USA/cross-sectional	Air force, army, marine corps, and navy/M and F	26,680/>18 years	Combination products, protein/AA, MVM, IVM	Online survey	67.95% of personnel used one or more supplements	Proportion of DS users (1 time/week) reporting 1 AE was 18% overall (palpitations, racing heart, abdominal pain, nausea, vomiting diarrhoea, muscle cramps, pain, weakness sleep disturbances, insomnia dizzy, confused, lightheaded, tingling, numbness, seizures, convulsions, tremors)
Knapik et al. 2022 B (3)	USA/cross-sectional	Air force, army, marine corps, and navy/M and F	26,880/> 18 years	MVM, IVM, proteins/AA, herbal products	Online survey	49% used any of DSs in the 6-month period	–
Knapik et al. 2022 C (60)	USA/cross-sectional	Air force, army, marine corps, and navy/M and F	26,681/> 18 years	MVM, IVM, proteins/AA, herbal products	Online survey	–	AE prevalence (≥ 1 AE) in any DS categories was 18.4% (palpitations, racing heart, abdominal pain, nausea/vomiting, diarrhoea, muscle cramps/pain/weakness, sleep disturbances/insomnia, dizzy/confusion/lightheaded, tingling/numb in extremities, and seizures/convulsions/tremors)
Knapik et al. 2022 D (61)	USA/cross-sectional	Air force, army, marine corps, and navy/M and F	146,365/> 18 years	MVM, IVM, proteins/AA, herbal products	Online survey	45% of SMs used ≥ 1 SRNS at least once per week in the past 6 months (sport drinks, bars, and gels: 32 ± 0.3, 27 ± 0.3, and 3 ± 0.1%, respectively)	Overall, the proportion of users reporting ≥ 1 AE was 2.0 ± 0.1%. (palpitations, racing heart, abdominal pain, nausea/vomiting, diarrhoea, muscle cramps/pain/weakness, sleep disturbances/insomnia, dizzy/confusion/lightheaded, tingling/numb in extremities, and seizures/convulsions/tremors)
Bukhari et al. 2021 (37)	USA/cross-sectional	Active duty soldiers/ M and F	289/> 18 years	MVM, IVM, protein/AA	Self-report questionnaire	75% used at least 1 type of DS per week (52% protein/AA, 47% MVM, and 35% combination of products)	Increased heart rate; tingling on face, skin, and arms; and itching near the nose

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Reference	Country/study design	Population/sex	Sample size and age of participants	Supplement type	Methods for data collection	Prevalence of supplement use	Adverse effects
Lui et al. 2019 (62)	Australia/cross-sectional	Australian veterans/M and F	15,355/> 18 years	Body-building supplements, energy supplements, weight loss supplements	Questionnaire	Overall use of supplements was 27.8% in deployment to Afghanistan, 22.0% in Iraq, current use 21.2% in post deployment	–
Kullen et al. 2019 (10)	Australia/cross-sectional	Army personnel/M and F	667/> 18 years	Caffeine, vitamin and mineral supplements, protein powders, creatine, AA	Questionnaire	74.5% of personnel reported using ≥ 1 DS/day, with ~26% reporting use of ≥5 types of DS at least once/week: caffeine (48.4%), vitamin and mineral supplements (34.8%), protein powders (27.9%), creatine (13.3%), and AA (13.2%)	–
Humphreys et al. 2019 (63)	USA/cross-sectional	US navy and marine corps personnel/M and F	1,708/30.89 ± 8.06 years	Vitamin, protein, herbal products	Self-report questionnaire	73% of personnel reported use of dietary supplements one or more times per week	Significant associations between vitamin supplement use and ICD-9-CM-diagnosed diseases of the nervous system and diseases of the musculoskeletal system and connective tissue
Hatch et al. 2019 (64)	USA/case-control	Soldiers/M and F	289/28 ± 6 years	Protein/AA, MVM, other DSs, combination products	Questionnaire	75% of soldiers used DS ≥1 time/week: protein/AA (52%), MVM (47%), and combination products (35%)	DS users scored higher in experience seeking and novelty than non-users
Baker et al. 2019 (11)	Australia/ cross-sectional	Active-duty soldiers/M and F	23,195/> 18 years	Protein/AA, MVM, other DSs, IVM, combination products	Online survey	Use of ≥ 1 DSs/week was reported by 77.1% of personnel: protein/AA (55.6%), MVM (38.2%), other DSs (37.8%), IVM (33.0%), and combination products (32.8%)	16% of regular DS users reported experiencing one or more side effects (palpitations, tingling or numbness in the face, fingers, arms, or legs, tremors or shaking, flushing, headache, abdominal pain, anxiety, and dizziness or confusion)
Knapik et al. 2018 (13)	USA/cross-sectional	US armed forces personnel/M and F	39,877/> 18 years	MVM, IVM, antioxidants, bodybuilding, herbals, weight loss, fish oil	Questionnaire	69% of personnel reported using DSs ≥ 1 time per week: MVM (50%), antioxidants (34%), IVM (33%), bodybuilding supplements (27%), fish oils (26%), herbals (16%), weight-loss supplements (16%)	–
van der Pols et al. 2017 (65)	Australia/cross-sectional	Australian defence force personnel/M and F	14,032/18–68 years	Bodybuilding, energy and weight loss supplements	Online survey	32.3% of participants used any of these supplements: bodybuilding (17.5%), energy supplements (24.5%), weight-loss supplements (7.6%)	–

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Reference	Country/study design	Population/sex	Sample size and age of participants	Supplement type	Methods for data collection	Prevalence of supplement use	Adverse effects
Knapik et al. 2016 (66)	USA/cross-sectional	Navy and marine corps personnel/M and F	1,683/> 18 years	MVM, protein/AA, combination products, IVM	Questionnaire	73% reported using dietary supplements one or more times per week: MVM (48%), protein/AA (34%), combination products (33%), and IVM (29%)	22% of dietary supplement users and 6% of nutritional supplement users reported one or more AEs; for combination products alone, 29% of users reported one or more AEs
Austin et al. 2016 A (20)	USA/cross-sectional	Active-duty soldiers/M and F	2006–2007 (n = 989) and 2010–2011 (n = 1,196)/> 18 years	MVM, IVM, protein/AA, combination products, herbal supplements	Standardized questionnaire on DS use	2006–2007 (56.1 ± 1.6%) 2010–2011 (63.9 ± 1.7%)	–
Austin et al. 2016 B (67)	USA/cross-sectional	Air force personnel/M and F	1,750/> 18 years	MVM, IVM, protein/AA, combination products, herbal supplements	Standardized questionnaire on DS use	DS were used by 68% of personnel: MVM (45%), protein supplements (33%), IVM (22%), combination products (22%), herbals (7%)	–
Austin et al. 2015 A (9)	USA/cross-sectional	Active-duty army personnel/ M and F	Deployed (n = 221), garrison (n = 1,001)	MVM, IVM, protein/AA, combination products, herbal supplements	Standardized questionnaire on DS use	82% of deployed and 74% of garrison soldiers used DSs ≥1 time per week over the past 6 months	–
Austin et al. 2015 B (68)	USA/ cross-sectional	Armed forces, military and coast guard personnel/M and F	4,400/> 18 years	MVM, IVM, protein, combination products, herbal products	Self-reported paper-and-pencil survey	69% of participants reported using DS ≥ 1 time/week for the 6 months prior to the survey: MVM (44%), protein supplement (32%), combination products (25%), IVM (22%), herbal supplement (8%) at least once a week	7% of DS users reported experiencing abnormal heart beats, 6% tremors, 5% stomach pain, 3% dizziness, and 3% numbness/tingling associated with the use of DS
Austin et al. 2015 C (69)	USA/cross-sectional	Coast guard personnel/M and F	1,033/> 18 years	MVM, protein, AA, IVM, combination products, herbal products	Questionnaire	70% of personnel reported using a DS at least 1 time/week: MVM (47%), protein supplements (33%), IVM (22%), combination products (23%), and herbal (9%)	–
Paisley 2015 (70)	USA/cross-sectional	Army soldiers/M and F	100/> 18 years	Protein, AA, multivitamin, ergogenic, fish oil, weight loss, herbal, joint and liver health supplements	Questionnaire	77% of respondents reported using at least one supplement during deployment	9% of respondents reported adverse effects of supplement use; no respondents reported serious complications of supplement use, drug interactions, or seeking medical care for supplement adverse effects

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Reference	Country/study design	Population/sex	Sample size and age of participants	Supplement type	Methods for data collection	Prevalence of supplement use	Adverse effects
Casey et al. 2014 (71)	UK/cross-sectional	Army soldiers under training/M and F	3,168/16–52 years	Creatine, AA, energy bars, Ca, fish oils, sodium bicarbonate, protein bars, powders and drinks, isotonic sports drinks, sports gels, folic acid, vitamin C, glucosamine, multivitamins, herbal remedies, Fe tablets, antioxidants, recovery drinks	Anonymous questionnaire	38% of the respondents reported current use of supplements: protein bars, powders and drinks (66%), isotonic carbohydrate-electrolyte sports drinks (49%), creatine (38%), recovery sports drinks (35%), multivitamins (31%), vitamin C (25%)	–
Austin et al. 2014 (72)	USA/cross-sectional	Military and coast guard personnel/M and F	5,536/> 18 years	MVM, IVM, protein/AA supplements, combination products, herbal supplements	Questionnaire	69% of participants reported using a DSs 1 or more times per week for the 6 months prior to the survey: MVM (43%), protein supplement (30%), IVM (28%), combination products (22%), herbal (9%) at least once a week	Some users reported feeling less friendly (more aggressive)
Kjertakov et al. 2013 (12)	Macedonia/cross-sectional	Ranger battalion and special force battalion//M and F	132/28 ± 3.4 years	Multivitamins, IVM, sports drinks, protein powder, glutamine, creatine, antioxidants, branched-chain amino acids, coenzyme Q10, ginseng, weight gainers, carnitine	Anonymous self-reported questionnaire	66.6% of the soldiers reported using supplements within the 3 months before the survey: multivitamins (50.0%), vitamin C (47.7%)	–
Boos et al. 2011 (73)	UK/cross-sectional	Soldiers/M and F	87/18–50 years	Proteins/AA, creatine, chromium	Questionnaire	56.3% admitted to a history of supplement use: proteins/AA (85.7%), creatine (34.3%), chromium (31.4%)	
Jacobson et al. 2012 (74)	USA/cross-sectional	Active-duty, reserve, and national guard/M and F	106,698/> 18 years	MVM, IVM, protein/AA supplements, combination products, herbal supplements	Self-report	46.7% of participants reported using at least one type of supplement and 22.0% reported using multiple supplements	–
Lieberman et al. 2010 (18)	USA/cross-sectional	Army soldiers/M and F	990/> 18 years	MVM, IVM, protein/AA supplements, combination products, herbal supplements	Questionnaire	53.2% consumed MVM (37.5%), protein and AA (18.7%), IVM (17.9%), combination products (9.1%), herbal supplements (8.3%)	–

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Reference	Country/study design	Population/sex	Sample size and age of participants	Supplement type	Methods for data collection	Prevalence of supplement use	Adverse effects
Young and Stephens 2009 (75)	USA/cross-sectional	Marine corps/M and F	323/17–29 years	Protein powders, energy drinks, vitamin supplements, fat burners	Self-report questionnaire	50% of respondents reported nutritional sports supplement use: protein powder (43%), post recovery workout drinks (36%), vitamin supplements (26%), creatine (26%), nitric oxide (16%)	–
Johnson et al. 2007 (76)	USA/cross-sectional	Rangers/M and F	294/23 years	MVM, IVM, protein/AA supplements, combination products, herbal supplements	Questionnaire	37% of the responders admitted using at least one dietary supplement (protein supplements were the most common supplement, followed by creatine and thermogenic)	–
Castillo et al. 2004 (77)	USA/cross-sectional	Marines/M and F	1,482/> 18 years	Stimulants, muscle mass/strength aids, weight loss, energy boosters, mood/mental ability aids, vitamins/minerals, or other substances used for general health	Self-report questionnaire	54% of the participants had used dietary supplements in the preceding year: muscle mass/strength aids (53%), energy boosters (28%), vitamins/minerals (27%)	–
Sheppard et al. 2000 (78)	USA/cross-sectional	Military personnel/M and F	133/30 ± 1 years	Creatine, protein, caffein, vitamin, mineral, herbal, β-hydroxy-β-methyl butyrate	Questionnaire	63.90% of personnel used creatinine or another dietary supplement: creatine (29%), protein (45%), caffeine (32%), vitamins (65%), minerals (47%), herbals (21%), β-hydroxy-β-methyl butyrate (10%)	–
Arsenault and Kennedy 1990 (79)	USA/cross-sectional	Army special forces and ranger training/M	2,215/18–47 years	Vitamin, mineral, and protein/pro-performance	Questionnaire	85% of the men reported past or present use of a supplement, 64% reported current use, and 35% reported daily use	–

AE – adverse effect; AA – amino acid; DMAA – 1,3-dimethylamylamine; DS – dietary supplement; IVM – individual vitamins and minerals; MVM – multivitamin or multimineral; M – male; F – female; SMs – military service members; SRNS – sport-related nutritional supplements

Table 2. *Subgroup analyses for the prevalence of DSs use in military population*

	Effect size (n)	Effect size (95% CI)[a]	p-value within[b]	I^2 (%)[c]	p-heterogeneity[d]
Sample size					
< 1,000	12	0.60 (0.52–0.67)	< 0.001	96.4	< 0.001
1,000–10,000	11	0.57 (0.49–0.64)	< 0.001	99.5	< 0.001
> 10,000	10	0.42 (0.29–0.56)	< 0.001	99.9	< 0.001
Country					
USA	23	0.62 (0.57–0.68)	< 0.001	100.0	< 0.001
Australia	4	0.33 (0.19–0.47)	< 0.001	99.9	< 0.001
UK	2	0.38 (0.37–0.40)	< 0.001	91.4	0.001
Germany	1	0.34 (0.27–0.41)	< 0.001	0.0	–
Macedonia	1	0.61 (0.57–0.73)	< 0.001	0.0	–
Supplement type					
MVM, IVM, AA/protein, or others	20	0.59 (0.50–0.69)	< 0.001	99.97	< 0.001
IVM or AA/protein	7	0.60 (0.43–0.78)	< 0.001	99.67	< 0.001
Body-building or energy supplements	4	0.38 (0.27–0.50)	< 0.001	99.75	< 0.001
Data collection method					
Online survey	26	0.61 (0.54–0.69)	< 0.001	99.92	< 0.001
Paper-based survey	5	0.57 (0.49–0.64)	< 0.001	99.99	< 0.001
Publication year					
2019–2023	10	0.53 (0.42–0.65)	< 0.001	99.99	< 0.001
2015–2018	10	0.62 (0.50–0.73)	< 0.001	99.85	< 0.001
2014 and before	11	0.56 (0.46–0.66)	< 0.001	99.73	< 0.001

AA – amino acid; CI – confidence interval; IVM – individual vitamins and minerals; MVM – multivitamin or multimineral
[a]Obtained from the random-effects model; [b]refers to the prevalence rate (95% CI); [c]inconsistency, percentage of variation across studies due to heterogeneity; [d]obtained from the Q-test

for further screening. The title and abstract of the studies were screened in the first stage, and 21,541 irrelevant articles were excluded. In the second stage, the full text of the 89 articles was critically reviewed of which 57 articles were excluded because they studied DSs prescriptions filled by the personnel; were case reports; studied the effects of a specific DSs supplementation on the military population; studied the effects of energy drinks on the personnel; and the full text was not available. Finally, 32 cross-sectional studies were included in the systematic review (Table 1) and 30 studies were considered for quantitative synthesis. No additional articles were found through forwarding and backward citation tracking of the eligible studies. The PRISMA diagram for the current study is presented in Figure 1.

Characteristics of Included Studies

The main characteristics of the included studies are presented in Table 1. The included studies were published from 1990 to 2023. In total, 350,375 military personnel aged over 18 years old were involved in this study. Except for one case, all of the included studies involved both genders of the personnel. The location of the studies was as follows: 24 in the USA, four in Australia, two in the UK, one in Germany, and one in Macedonia. The military personnel included in the studies were service members, wing commanders, air force, army, marine corps, navy, active-duty soldiers, veterans, armed forces, defence force, coast guard, ranger battalion, special force battalion, reserve, and national guard personnel. The main DSs evaluated in the included studies were multivitamin or multimineral (MVM), individual vitamins and minerals (IVM), proteins or amino acids, omega-3 fatty acids, herbal and combination products, caffeine, creatine, antioxidants, fish oil, bodybuilding or weight loss supplements, and DSs containing 1,3-dimethylamylamine. The methods used for data collection in the included studies were online surveys, self-report questionnaires, and interviews.

Risk of Bias Assessment

The results of the risk of bias assessment of the included studies using the Joanna Briggs Institute critical appraisal checklist are illustrated in S Table 3. As shown in S Table 3, the overall quality score for the included studies ranged from 7 to 9 of the maximum 10 scores and 7 of the maximum 9 scores, respectively. Most of the included studies did not report adequate information about the sampling method, response rate, and conducting data analysis with sufficient coverage of the identified sample. However, the majority of the studies generally included large sample sizes that were more representative of the average in the community and the outcome assessments were appropriate.

Prevalence of DSs use in Military Personnel

Thirty-two studies were identified that evaluated the prevalence of DSs use in military personnel. Table 1 presents the

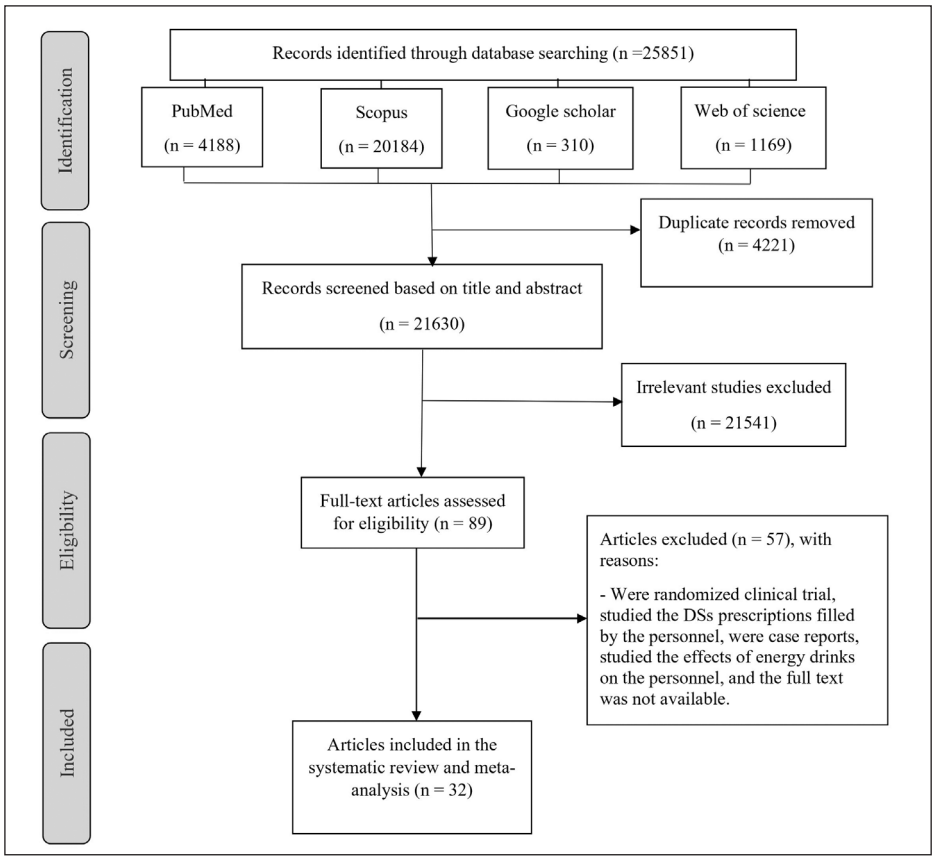

Fig. 1. *PRISMA diagram for the process of the search and study selection.*

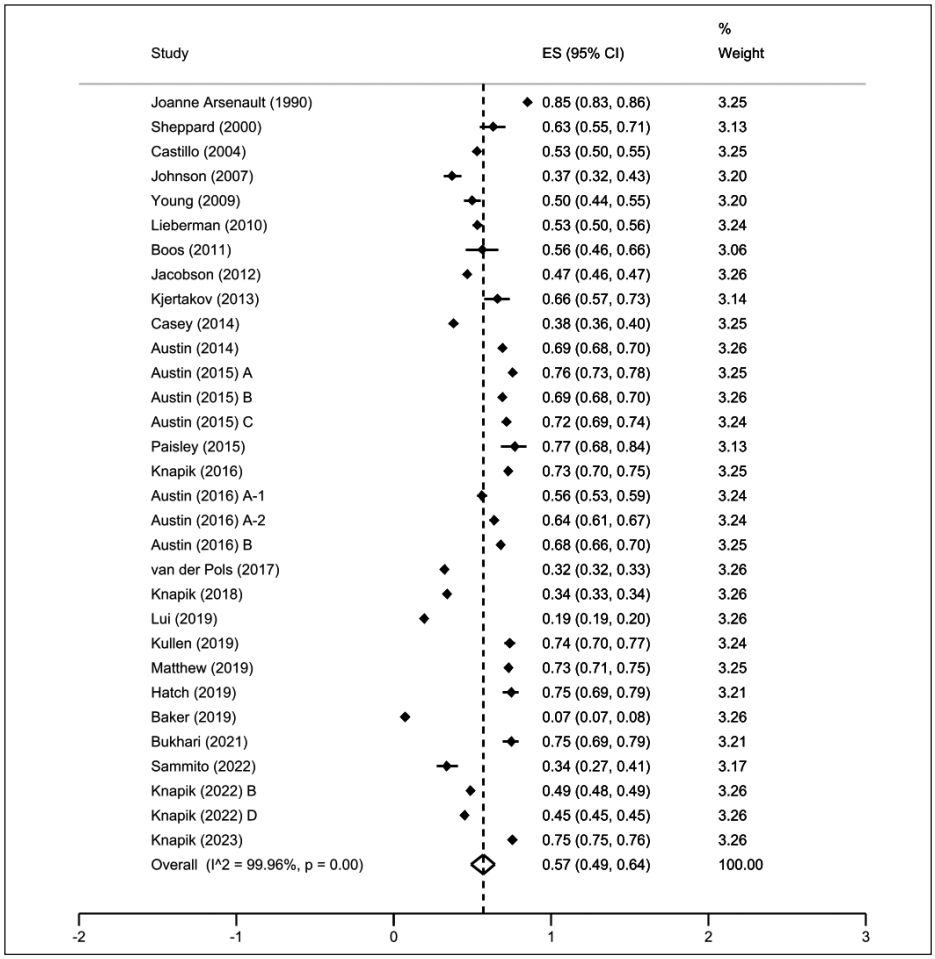

Fig. 2. *Forest plots of the prevalence of DSs use among the military population.*

prevalence rate of DSs use by the military population among the included studies. Except for one case, all of the included studies were included in the meta-analysis. The prevalence rate of DS use in the overall military population was 57% (95% CI: 49–64) with significant heterogeneity ($I^2 = 99.96\%$, $p < 0.001$) (Fig. 2). Subgroup analysis revealed that the prevalence of DSs use in the studies with sample size above 10,000 (42%, 95% CI: 29–56) was lower than in the other studies (Table 2). Moreover, except for one study that was conducted in Macedonia, the prevalence of DSs use in the studies that were carried out in the USA (58.2%, 95% CI: 47.6–68.7) was higher than in the other countries. In addition, the prevalence of DSs use was higher in the studies that were performed in the years 2015–2018 (62%, 95% CI: 50–73) and used online surveys for data collection (61%, 95% CI: 54–69). The prevalence rate of body-building and energy supplement use (38%, 95% CI: 27–50) was lower than other DSs. The Egger's tests indicated a small study effect ($p = 0.001$), however, there is not an asymmetry in the funnel plot (supplementary S Fig. 1).

Adverse Effects of DSs Use in Military Personnel

Eleven studies were found to evaluate the AEs of DSs use among the military population and seven studies presented the rate of reported AEs. The prevalence rate of AEs following DS use among the seven studies was 2%–18.4%. Based on the meta-analysis result, the prevalence of DSs use AEs was 13.0% (95% CI: 6–20) with a high heterogeneity ($I^2 = 99.89\%$, $p < 0.001$) among them (Fig. 3). The Begg's tests indicated no small study effect ($p = 0.881$), and the asymmetry was also not observed in the funnel plot (supplementary S Fig. 2). As shown in Table 1, the AEs reported by the military personnel involved in the included studies were palpitations, abdominal pain, nausea, vomiting, diarrhoea, muscle cramps, pain, weakness, sleep disturbances, insomnia, confusion, lightheaded, numbness, seizures, convulsions, tremors, increased heart rate, tingling on face, skin and arms, itching near the nose, flushing, headache, anxiety, and dizziness. However, no military personnel reported serious complications of DSs use or seeking medical care for supplement AEs.

DISCUSSION

The prevalence of DS use has been reported in several military and civilian studies. It is well documented that military staff use DSs more commonly than civilians (9, 18). According to the current study's findings, the prevalence of DS use in the overall military population was 57%; moreover, this rate was higher in the studies carried out in the USA, the studies with a sample size lower than 10,000 participants, and studies that used an online survey for data collection. The studies that were conducted recently (during 2019–2023) reported a lower prevalence of DSs use compared to the others. Moreover, the prevalence of body-building and energy supplement use was lower than other DSs. The prevalence of MVM and IVM use was higher than other DSs among the military population. Under this study, Knapik et al. also indicated that MVM supplements were the most commonly used DSs among military personnel (17). Similarly, in the athletes and the general population, MVM supplements were also the most commonly consumed DSs (34, 35).

The widespread use of DSs in different populations could have various reasons. DS use has been linked with health-promoting activities, with consumers seeking a healthy lifestyle (36). In the military population, the use of DSs may be general health preservation and improvement, physical performance enhancement, and provision of energy (17, 37). Studies have demonstrated that people who use DSs care more about their health and wellbeing than those who do not use DSs (38). A population-based cross-sectional study found that soldiers undertaking high-intensity interval training and showing healthy behaviours often used performance-enhancing and weight-reducing DSs (39). Athletes were also one of the populations that represent a major part of dietary supplement users (40). Similar to military personnel, it appears the main reasons for DS use are improving health, improving athletic performance, and accelerating recovery (14).

The previous meta-analysis conducted by Knapik et al. demonstrated that female personnel used DSs more commonly than male personnel in the army (65% vs. 55%), air force (76% vs. 60%), navy (71% vs. 60%), and marine corps (71% vs. 61%) (17).

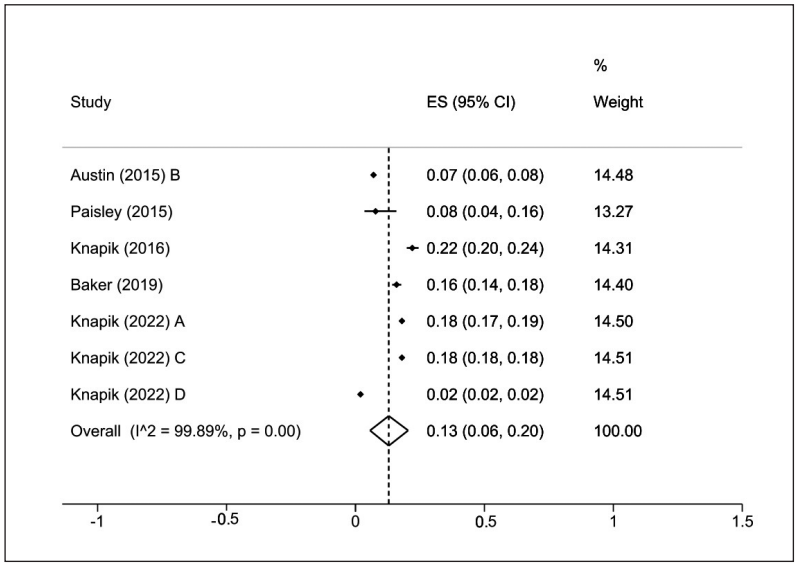

Fig. 3. *Forest plots of the prevalence of DSs use AEs among the military population.*

However, most studies on athletes indicated that the prevalence of DS consumption was higher in males compared to females (41–43). It was demonstrated that female athletes were more likely to consume DSs for health reasons, and male athletes were more likely to consume DSs to enhance performance (44–46).

Some consumers incorrectly assume that the safety and efficacy of DSs are controlled by the Food and Drug Administration (47). However, there is insufficient evidence to support the use of many DSs, with some even having AEs (48). This study's results demonstrated that the prevalence of AEs following DSs use was 13.0%. DS consumers may experience AEs due to excessive intake, contaminants (secondary to inadequate quality control during production), allergic reactions to ingredients, dangerous ingredients, interactions with prescribed medications, or unlisted or illegal constituents (49, 50). Based on the included studies' findings, some AEs reported by the military personnel following DS use were palpitations, abdominal pain, vomiting, diarrhoea, nausea, muscle cramps, weakness, insomnia, sleep disturbances, confusion, lightheaded, tingling, seizures, numbness, convulsions, tremors, tachycardia, pruritus, flushing, headache, anxiety, and dizziness. However, no military personnel reported serious complications of DS use or seeking medical care for their AEs. A 2.5-year experiment showed that AEs were highest with products marketed for weight loss and were most common in the gastrointestinal, cardiovascular, and nervous systems (27). Another population-based study indicated that the incidence of AE was higher for the combination of products and purported prohormones. They also reported that younger individuals, women, those with higher BMI, and those consuming a greater number of DSs were at higher risk for AE incidence (31).

Many soldiers lack knowledge or misunderstand the efficacy and safety of DSs; one study found that most soldiers confidently believed DSs are safe and deliver the advertised benefits (51) and were unaware of the related regulatory requirements. Moreover, several reports have discussed AEs of DS consumption in this population (28, 29). One comprehensive survey declared that DS consumption is widespread among military personnel and deemed it vital to perform long-term evaluations of the safety and efficacy of these supplements (52). Also, in light of such widespread usage and related concerns, understanding why military personnel are opting to use DSs is crucial. As a solution, providing evidence-based facts regarding the AEs of DS use and conducting nutritional education interventions about various DSs among the military population is suggested.

As mentioned above, most military personnel usually use DSs to ensure adequate nutrient intake and to improve their health and performance (17, 37). In addition to DSs that may have AEs, diet-based approaches are useful methods for enhancing human health and performance. Dietary diversity (DD) as an indicator of nutrient adequacy can benefit human health in several dimensions (53, 54). Individuals with acceptable DD had better nutritional and health status (54, 55). Higher DD was also associated with a higher intake of protein (56). Adequate protein intake can help in maintaining muscle function (57). Thus, the participants with a high DD had a high protein, vitamins, and antioxidant nutrients intake (53, 54), all of which have been shown to prevent frailty and improve health and physical performance. It is important to strengthen healthy dietary behaviour education for the military population to increase their awareness regarding healthier and diet-based methods for enhancing general health and physical performance.

This study encountered certain limitations, including the significant heterogeneity among studies, numerous ranges of the included study populations, different assessment methods and questionnaires for collecting information about DSs use in military personnel, and heterogeneity of the studied DSs.

CONCLUSIONS

This systematic review and meta-analysis indicated that the prevalence of DSs use was high (54.1%) among military personnel. Moreover, some of the included studies reported various AEs following DSs use in military personnel. Promotion of military population knowledge and attitudes regarding DSs safety and efficacy by nutritional educational interventions could be effective in preventing the abuse or misuse of DSs and consequent AEs in the military population. More population-based studies are needed to determine the exact prevalence of DSs use and specify the AEs of their use among different military populations.

Electronic Supplementary Materials

This article contains supplementary material available at https://doi.org/10.21101/cejph.a8321

Authors' Contributions

BA and RMG – conception and design; RMG data collection, statistical analysis, drafting the manuscript; BA and MR revised the manuscript. All authors approved the final version of the manuscript.

Acknowledgments

We gratefully acknowledge the financial support of the Vice-Chancellor for Research of Tabriz University of Medical Sciences, Tabriz, Iran (Grant no. 72070).

Adherence to Ethical Standards

The protocol of the current study was registered and certified by the Research Vice-Chancellor of Tabriz University of Medical Sciences, Tabriz, Iran (Ethical code: IR.TBZMED.VCR.REC.1402.109).

Conflicts of Interest

None declared

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Received June 14, 2024
Accepted in revised form February 8, 2025