

## **Trend and prevalence of overweight and obesity among the military population – a systematic review**

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**Running title:** Overweight and obesity among the military population

**Abstract:**

Prevalence of overweight and obesity are escalating globally among the general population. However, there are limited evidence on the trends and prevalence of overweight /obesity in the military setting. Increased rates of injuries, low work productivity, incurred higher healthcare costs and prematurely discharge from service are consequences of overweight/obesity among the military. Therefore, we aimed to systematically describe the trends and prevalence of overweight and obesity in the military population, by regions and military service branches. Databases including PubMed, Scopus, Web of Science and Google Scholar were used. Inclusion criteria were military population (inclusive of all service branches) with BMI reported as the overweight/obesity indicator. Population related to military but not exclusively military personnel such as the retirees, the veterans and their dependents were excluded. From the 27 included studies, 13 were published between year 2010 to 2014 and half were conducted in the United States. Overall, studies showed increasing trend in the prevalence of overweight (30% to 50%) and obesity (2% to 30%); only one study showed a decreasing trend of 0.9% and 0.6% for the prevalence of overweight and obesity respectively. However, the rates of increment differed between countries, where Asian countries demonstrated lower overweight prevalence compared to the United States and the European countries. In conclusion, the military population is not protected from overweight and obesity. Interventions should be implemented to prevent overweight / obesity among the military personnel.

**Keywords:** trend, prevalence, overweight, obesity, military

## Introduction

Prevalence of overweight and obesity is increasing in the general population. Almost all the countries across the world show a rise in both overweight and obesity prevalence, albeit at different rates of increment. However, these studies understandably did not include sample from exclusive groups or organization such as the military. The high prevalence of overweight and obesity in the general population, especially among adolescent and young adult has affected the military recruitments (1). These were evidenced among the Polish conscripts where their prevalence of overweight has risen from 10.5% in 2000 to 15.5% in 2010 (2). The prevalence of obesity also showed an increase from 2.5% to 3.8% over the same period. Similar trends were observed among the applicants the US military whereby the prevalence of overweight and obesity increased from 22.8% to 27.15 and from 2.8% to 6.8% respectively from 1993 to 2006 (3). Recruits with high BMI were more likely to sustained injuries during military training compared to their normal weight comrades, thus incurred higher healthcare costs (4, 5). They were also more likely to be prematurely discharged from the military due to their inability to perform their tasks as a consequences of overweight and obesity (6, 7).

Unlike voluminous publications on overweight and obesity among the general population, studies in the military setting are relatively lacking. The military population are synonyms with strict entrance screening, strenuous basic training and highly physically demanding job. Therefore, they are assumed to be immune from obesity. However, several studies had shown otherwise, with comparable prevalence to the general population. To the best of our knowledge, there is only one systematic review on obesity in military population (8), which focused on the factors and treatment of obesity. Thus, this review aimed to collectively and systematically review the trend and prevalence of overweight and obesity in the military population.

## Methods

### Inclusion/exclusion criteria

Studies were included in this systematic review if the study setting was in military population and reported outcomes measuring the prevalence of overweight and/or obesity. Only studies published after the year 2000 and in English language are eligible for this review. In addition, the measurement of overweight and obesity must be BMI as its proxy. Any studies that used other measurements of adiposity such as BF% or WC and using other classification such as Asian classification were excluded. In this review, military population is inclusive of all the three main service branches; Army, Navy, and Air Forces. Studies that measure the prevalence in a population related to military but not exclusively military personnel such as the retirees, the veterans and their dependents were also excluded.

### Selection strategy and procedures

PubMed (US National Library of Medicine, National Institutes of Health), Scopus and Web of Science were used to conduct a systematic search to identify relevant publications that fulfilled the inclusion criteria to be included in this review. The search terms used were: (Overweight[Title] OR Obesity[Title] OR BMI[Title] OR Body Mass Index [Title]) AND (Military[Title] OR Army[Title] OR Navy[Title] OR Air Force[Title] OR Armed Forces [Title]) AND ("2000/01/01"[Date - Publication] : "3000"[Date - Publication]) AND English[Language]) NOT (Child\*[Title] OR Pediatric[Title] OR Teen\*[Title] OR Adolescent[title]) NOT (Family[Title] OR Families[Title] OR Parent\*[Title] NOT (Dependent\*[Title] OR Veteran\*[Title] OR Civilian[Title])). This has yielded a total of 269 articles. Another 34 relevant articles from Google Scholar search (9) using the same keywords were added to the pool, making the total 303 articles for review. The study selection process was carried out by two investigators (AO and HLL) independently using a standardized form. Discrepancies were resolved through discussion, while unresolved discrepancies were referred to the third investigator (FMM). Full text articles for the selected studies were then downloaded for screening. The list of the excluded papers and the reason for rejection was recorded. Data were extracted directly into an evidence table by AO and HLL.

A modified Quality Assessment Tool (QAT) was created based on the National Institute of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross Sectional Studies (10), the Critical Appraisal Checklist for Studies Reporting Prevalence Data from the Joanna Briggs Institute (11), and studies by Saab et al. (2016) (12) and Munn et al. (2014) (13). The QAT contained 9 items (Table 1). The first five items assessed the general quality of the selected studies, while the remaining items were designed specifically to determine the trend and prevalence of overweight and obesity in the military population. A total score of 0 – 33% is considered weak, while 34 – 66% is moderate and 67 – 100% is high quality studies based on the modified QAT criteria (12). This review did not proceed to meta-analysis in view of different time where the studies were conducted and limited number of studies between different military branches.

**Table 1: Quality Assessment Tool**

Items	Score	
	0	1
1. Research questions and research objectives clearly stated		
2. Study population specified (military) and defined		
3. Sample likely to be representative		
4. Study subjects and setting described in detailed		
5. Sample size estimation and justification provided		
6. Overweight and obesity was the main outcomes measured		
7. BMI was classified according to WHO classification		
8. Prevalence of overweight and/or obesity clearly stated		
9. Methods of BMI measurement clearly stated		

0 = Not reported/ Not Available/ Not Satisfactory    1 – Reported

Score calculation; Sum of score (Item 1 -9) /9 \* 100

Score classification; 0 – 33.9% = weak, 34.0 – 66.9% = moderate, 67.0 - 100% = strong

## Results

### General description of studies

A total 303 articles were retrieved from Scopus, Web of Science, PubMed and Google Scholar.

After study selection, only 27 articles were eligible to be included in the review (Figure 1).

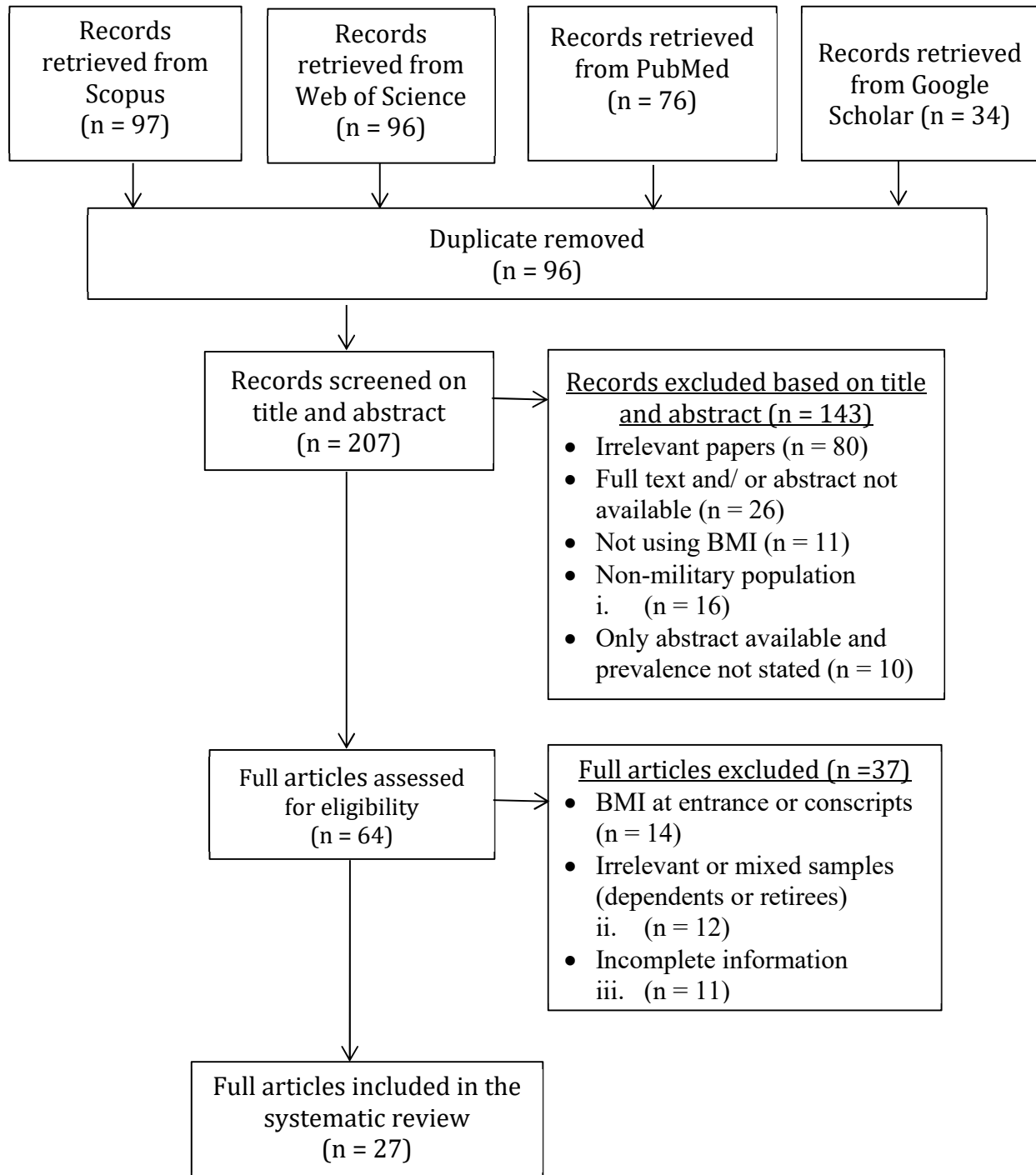


Figure 1: Prisma study flow

Quality assessment score was given to the selected studies based on the modified QAT (Table 2). Majority of these studies (70%) were considered strong (QAT score  $\geq 67\%$ ) and the remaining 30% were moderate (QAT score between 34% and 66.9%). Only two studies (14, 15) fulfilled all the criteria (QAT score 100. There were eight studies with a score of 66.7%, which was the lowest score (16-23).

Based on the nine items assessed, four items namely: (1) Research questions and research objectives clearly stated, (2) Study population specified (military) and defined, (3) Study subjects and setting described in detailed, and (4) Prevalence of overweight and/or obesity clearly stated; were fulfilled by all studies (100%), All studies, except for study among the Korean Army (24) used the WHO BMI classification. This study defined overweight as having BMI of 23 to 24.9 kg/m<sup>2</sup>, obese class I as 25 to 29.9 kg/m<sup>2</sup> and obese class II as  $\geq 30$  kg/m<sup>2</sup>. However, this study was still included in the overall review with reclassified prevalence according to the WHO classification. Majorities of the studies (85.2%) failed to report the sample size estimation and justification. Only four studies mentioned how their studies arrived to the specified sample size (14, 15, 25, 26). Method of BMI measurement was another item that scored poorly. Only ten studies (33.0%) reported clearly how height and weight were measured (14, 15, 24, 27-33). Standardised methods of anthropometric measurement may probably be the reason why these methods were not described.

**Table 2: Quality Assessment Summary – based on extracted studies (n = 27)**

Study	Quality Assessment Item									Score (%)
	1	2	3	4	5	6	7	8	9	
Payab et al. (2017)	1	1	0	1	0	1	1	1	1	77.8
Fajfrova et al. (2016)	1	1	1	1	0	0	1	1	0	66.7
Hruby et al. (2016)	1	1	1	1	0	0	1	1	0	66.7
Langton et al. (2016)	1	1	1	1	1	0	1	1	0	77.8
Urban et al. (2016)	1	1	1	1	0	0	1	1	0	66.7
Lennon et al. (2015)	1	1	1	1	0	0	1	1	0	66.7
Reyez-Guzman et al. (2015)	1	1	1	1	0	1	1	1	0	77.8
Collee et al. (2014)	1	1	1	1	0	0	1	1	0	66.7
Eilerman et al. (2014)	1	1	1	1	0	1	1	1	0	77.8
Sanderson et al. (2014)	1	1	1	1	0	1	1	1	1	88.9
Smith et al. (2014)	1	1	1	1	0	0	1	1	0	66.7
Horaib et al. (2013)	1	1	1	1	1	1	1	1	0	88.9
Gregg et al. (2012)	1	1	1	1	0	1	1	1	0	77.8
Smith et al. (2012)	1	1	1	1	0	1	1	1	0	77.8
Bae et al. (2011)	1	1	1	1	0	1	0	1	1	77.8
Fear et al. (2011)	1	1	1	1	0	1	1	1	1	88.9
Rona et al. (2011)	1	1	0	1	0	1	1	1	1	77.8
Sundin et al. (2011)	1	1	1	1	1	1	1	1	1	100.0
Sedek et al. (2010)	1	1	1	1	1	1	1	1	1	100.0
Mullie et al. (2009)	1	1	1	1	0	1	1	1	0	77.8
Siebert et al. (2009)	1	1	0	1	0	1	1	1	1	77.8
Gantt et al. (2008)	1	1	1	1	0	1	1	1	0	77.8
Kyrolainen et al. (2008)	1	1	1	1	0	0	1	1	0	66.7
Napradit et al. (2007)	1	1	1	1	0	1	1	1	0	77.8
Kress et al. (2006)	1	1	1	1	0	0	1	1	0	66.7
Mazokopakis et al. (2004)	1	1	0	1	0	1	1	1	1	77.8
Lindquist et al. (2001)	1	1	1	1	0	1	1	1	1	88.9

Quality assessment, n (%): Weak (0 – 33.9%) = 0 (0%), Moderate (34 – 66.9%) = 8 (29.6%), Strong (67 – 100%) = 19 (70.4%)

**Table 3: Quality Assessment Summary – based on assessment items**

<b>Items</b>	<b>Studies fulfilled the criteria (%)</b>
1. Research questions and research objectives clearly stated	100.0
2. Study population specified (military) and defined	100.0
3. Sample likely to be representative	85.2
4. Study subjects and setting described in detailed	100.0
5. Sample size estimation and justification provided	14.8
6. Overweight and obesity was the main outcomes measured	66.7
7. BMI was classified according to WHO classification	96.3
8. Prevalence of overweight and/or obesity clearly stated	100.0
9. Methods of BMI measurement clearly stated	37.0

**Table 4: Characteristics of selected studies**

Author (Year)	Country (Service)	Year of Survey	Sample size	Prevalence		BMI mean (SD)	Attributable Factors
				Overweight	Obesity		
1. Payab et al. (2017)	Iran (Iranian Army)	2015 to 2016	Male: 2,200	Male: 47.6%	Male: 15.5%	26.4 (4.6)	Not Available
2. Fajfrova et al. (2016)	Czech Republic (Czech Army)	1999 to 2009	Male:	Male:	Male:	Male:	Not Available
			1999: 6,154	1999: 52.0%	1999: 14.4%	1999: 26.6 (3.3)	
			2000: 6,404	2000: 52.6%	2000: 15.6%	2000: 26.3 (3.3)	
			2001: 6,161	2001: 53.3%	2001: 15.5%	2001: 26.8 (3.3)	
			2002: 4,995	2002: 52.4%	2002: 14.3%	2002: 26.6 (3.3)	
			2003: 5,306	2003: 52.7%	2003: 15.3%	2003: 26.7 (3.3)	
			2004: 4,056	2004: 52.5%	2004: 14.3%	2004: 26.7 (3.3)	
			2005: 5,021	2005: 54.6%	2005: 13.1%	2005: 26.3 (3.2)	
			2006: 5,419	2006: 54.1%	2006: 12.8%	2006: 26.6 (3.3)	
			2007: 5,786	2007: 55.8%	2007: 12.0%	2007: 26.5 (3.1)	
	2008: 7,057	2008: 57.1%	2008: 12.8%	2008: 26.7 (3.1)			
	2009: 7,496	2009: 57.1%	2009: 14.5%	2009: 26.9 (3.2)			

SD – Standard Deviation

## Publication and survey year

Majority of the studies (70%) were published during the year 2010 and above, with seven out of those were published between 2015 and 2017 (Figure 2). The latest publication retrieved was in 2017 (27), and the oldest study was published in 2001 (33). There were five studies started before the year 2000 (16, 32-35), while two studies ended before the year 2000 (32, 33). Around half of these studies were either started (48%) or completed (56%) between 2005 and 2009. Most of these studies (13 out of 27) were conducted within a specific year. The longest span of years covered was 13 years (34, 35) and 10 years (16, 17). While the shortest span of study were six months (36) and five months (32). The remaining eight studies were conducted within one year to seven years period.

## Study setting and sample size

About half of the studies ( $n = 13$ ) were conducted in the United States (Table 4). One third were carried out in the United Kingdom (UK) and European countries including two studies in Belgium (20, 35) and one study each in Germany (30), Finland (22), and Greece (32). Only three studies were from the Asian countries ie: South Korea (24), Thailand (36), and Malaysia (14). Two studies were conducted in the Middle Eastern countries including from Iran (27) and the Kingdom of Saudi Arabia (26). The Army being the biggest military branch in most nations was the most researched group with 13 studies. Another nine studies were carried out in the overall Armed Forces, which included the Army, Navy, Marines and the Air Forces. There were four studies conducted in the Navy population (14, 19, 37, 38), and only one study among the Air Forces personnel (25, 31).

The 27 selected studies were conducted between 1992 and 2017. The total sample involved was more than 5.7 million military personnel. Study with the biggest sample size was conducted between 2009 and 2012 totalling up to more than 3.6 million Active Duty military personnel in the US (39). Three more studies with a big sample size of more than 300,000 to more than 700,000 participants were also from the US (17, 19, 25). Around 70% or 19 studies had a sample size ranging from 2,000

to 7,000 participants. Only four studies had a sample size of less than 1,000 participants (14, 30-32). Study with the lowest sample size was by Siebert et al., which involved only 192 US Air Forces personnel (31).

### Trend and prevalence of overweight and obesity

Out of 27 studies, only seven reported prevalence over several years, thus establishing the trend in the same population (16, 24, 33-35, 39, 40). The prevalence of overweight and obesity did not show consistent increments but rather fluctuating between the years surveyed. The rates of increment also differed between countries.

#### (i) Prevalence of overweight

In terms of overweight, the Belgian Army recorded the highest increment (4.6%) in the prevalence of overweight between 1992 (30.5%) and 2005 (35.1%) (35). While among the males, the South Korean Army showed the highest rise of 7.6% over six years period between 2002 (32.7%) and 2008 (40.3%) (24). The highest increment in the prevalence of overweight among females (4.5%) was lower than males, recorded by the US Armed Forces between 1995 and 1998 (33). On the contrary, only one study showed a decreasing trend of 0.9% in the overall overweight prevalence among the US Active duty personnel between 2002 (48.5%) and 2005 (47.6%) (40). The average increase in the prevalence of overweight (calculated from these studies) was higher among males compared to females with 4.5% and 1.5% respectively.

Generally, the prevalence of overweight among females was lower than males. The overall overweight prevalence ranged from the lowest of 27.1% (2005) in the Royal Thai Army (36) to the highest of 54.2% (2009) in the US Air Forces personnel (31). Among males, the Czech Army and the Greek Army recorded the highest and the lowest overweight prevalence of 57.1% (2009) and 26.6% (1998) respectively. Meanwhile, the US Active Duty personnel recorded the highest overweight prevalence among females with 41.2% (2010), and the lowest overweight prevalence were among

the South Korean Army with 11.5% (2002). In general, the military population in the Asian countries demonstrated lower overweight prevalence compared to the US and the European countries.

## (ii) Prevalence of obesity

The increase in the prevalence of obesity was relatively lower compared to the increase in the prevalence of overweight. The US Armed Forces showed the highest increment in the prevalence of overall obesity (34), with a 7.7% rise recorded between 1995 (5.0%) and 2008 (12.7%). The South Korean Army had demonstrated the highest increase in both male and female obesity with 1.55% and 0.32% increment respectively (24) recorded between 2002 and 2008. The study among the US Active Duty personnel conducted between 2009 and 2012 was the only study that showed a decreasing trend in the prevalence of overall (0.6%), male (0.1%) and female (0.5%) obesity (39).

The highest overall obesity prevalence was 18.9%, reported by the US Active Duty personnel in 2009 (39). Meanwhile, the lowest overall obesity prevalence (4.9%) was reported in the Royal Thai Army in 2004 (36). The Kingdom of Saudi Arabia Army stood out with the highest prevalence of obesity among the males with 29.9% in 2009 (26). The next highest male obesity prevalence was 20.4%, which was reported among the US Active Duty personnel in 2009 (39). The South Korean Army recorded the lowest male and female obesity prevalence with 2.1% (2000) and 0.89% (2004) respectively (24). The Czech Army recorded the highest female obesity prevalence in 2000 with 14.6% (16). Similarly, the Asian countries seemed to show lower obesity prevalence compared to their Western counterparts.

## (iii) Prevalence by regions

The prevalence of overall overweight ranged from 54.2% (31), which was recorded among the US Air Forces in 2007 to the lowest of 29.6%, recorded among the US Army between 2005 and 2006 (18). Majority of these studies (89%) reported an overall prevalence above 40%. Only three of the latest publications reported an overall overweight prevalence of less than 35% (17, 18, 25). All four studies that provided the overweight prevalence for males and females showed that overweight

prevalence among males were higher (50% to 60%) compared to females (20% to 40%) (21, 23, 33, 39).

The overall prevalence of obesity among the US personnel ranged from 18.8% (31) to 4.2% (25). Majority of these studies (77%) reported an overall obesity prevalence of more than 10%. Meanwhile, among the US male personnel, the prevalence of obesity ranged from 9.8% (23) to 20.4% (39). These figures were higher than the US female personnel whose obesity prevalence were between 3.8% (23) to 10.7% (39).

Among the European countries, the Belgian Army recorded the highest and the lowest overall prevalence of overweight. The lowest was recorded between 1992 and 1994 with 30.5%, but this has steadily increased to 35.1% between 2003 and 2005 (35). In 2013, the Belgian Army recorded the highest overall overweight prevalence of 48% (20). Meanwhile, the overall overweight prevalence from other European countries was around 40%. On average, the prevalence of overweight among males was around 45%. However, the Czech Army was the only group that has consistently recorded an overweight prevalence of more than 50% since 1999, with the highest prevalence of 57.1%, which was recorded in 2008 and 2009 (16). On the contrary, the female Czech Army recorded the lowest overweight prevalence, which was below 30% since 1999. The highest prevalence recorded was 26.2% in 2009 (16). There were only two other studies that reported female overweight prevalence in 2007; the British Army with 30% (39) and the UK Armed Forces with 33% (15).

The overall obesity prevalence among the European countries was around 11% to 13% with the exception of the Belgian Army whom recorded a lower prevalence of 4% to 6% between 1992 and 2005 (35). On average, the males and females recorded an obesity prevalence of 10% to 15% and 5% to 15% respectively.

There were only two studies from the Middle Eastern countries involving the Iranian Army (27) and the Saudi Arabian Army (26). The overall and males overweight prevalence was 40.9% in the Saudi Arabian Army and 47.6% in the Iranian Army respectively. However, the participants in the Iranian

Army study were sampled from the hospitalised personnel, which could have introduced a selection bias. The overall ranged from 15% to 30%.

Among the studies conducted in the Asian region, i.e. the Korean Army between 2000 and 2008 (24), the Royal Malaysian Navy in 2004 (14), and the Royal Thai Army in 2005 (36); the overall overweight prevalence ranged from 27% to 32%. Meanwhile, the overweight prevalence for Asian males and females ranged from 30% to 40% and 10% to 15% respectively. The prevalence for overall, male and female obesity were all less than 5% except for the study in the Royal Malaysian Navy, which recorded 7.2% for male obesity (14).

The prevalence of overweight for overall, male and female were comparable between the US, Europeans and Middle Eastern countries, although there were no data available for female prevalence from the Middle Eastern countries. On the contrary, the overweight prevalence among the Asian countries was lower for all categories (Table 4).

Similar patterns were observed for the prevalence of obesity except the Middle Eastern countries had higher overall prevalence of obesity compared to the US and European countries. However, data from the Middle Eastern country was reported from a single study (26) only. The prevalence of obesity among the Asian countries was much lower and did not exceed 5% except for one study among the Royal Malaysian Navy that recorded male prevalence of 7.2% (14).

**Table 5: Estimated overweight and obesity prevalence for various country and regions**

Country/ Region	No. of studies	Estimated Overweight			Estimated Obesity		
		Prevalence			Prevalence		
		Overall	Male	Female	Overall	Male	Female
United States	13	40-50%	50-60%	20-40%	10-20%	10-20%	5-10%
Europeans	9	40%	45%	30%	11-13%	10-15%	5-15%
Middle Eastern	2	40%*	48%*	NA	30%*	15%*	NA
Asians	3	30%	35%	12%	2-5%	2-7%	1-4%

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NA – Not Available

\* Based on a single study

#### (iv) Prevalence by military service branches

There were 13 studies that described the prevalence of overweight and obesity in the Army personnel. The prevalence of overall overweight ranged from 30% to 50%, with the highest of 53.4% recorded in 2012 among the US Army (39). While the lowest overall overweight prevalence of 27.1%, recorded in the Royal Thai Army in 2007 (36). Overall, male Army personnel recorded higher overweight prevalence with an average of 40% to 55% compared to female Army personnel with an average of 20% to 30%. The highest and the lowest overweight prevalence for male Army personnel was 57.1% (Czech Army) (16) and 28.3% (Royal Thai Army) (36) respectively. Meanwhile, for female Army personnel, the highest overweight prevalence was 41% (US Army) (39), and the lowest was 11.1% (UK and Germany Army) (30).

The overall and male Army personnel obesity prevalence averaged around 10% to 20%. Eilerman et al. (2009) recorded the highest prevalence for both overall and male with 18.9% and 20.4% respectively (39). Meanwhile, the Korean Army recorded the lowest overall and male obesity prevalence at 2.1% (24). Although, these were recorded in 2000, and the trend was increasing since

then, the Korean Army overall and male obesity prevalence did not exceed 4.0%. The obesity prevalence among the female Army personnel was all less than 10%, except for the Czech Army that recorded 14.6% in 2000 (16). This has declined since then and remained below 10% since 2004. The Korean female Army obesity prevalence was the lowest (1.45%) (24).

A total of eight studies combined all the main service branches of the Armed Forces including Army, Navy, Air Force (15, 25, 26, 29, 32) and some studies included the Marine (33, 34, 40) as well. The overall overweight prevalence among the Armed Forces ranged from 33% (25) to 54% (33). Both were recorded in the US Armed forces between 2008 and 2015, and in 1998 respectively. While the range for the female overweight was between 25% and 30%, the male prevalence showed larger variation. The lowest male overweight prevalence (26.6%) was recorded in the Greek Army in 1998 (32), and the highest (58.6%) was recorded in the US Armed Forces in 1998 (33). More recent study among the US Armed Forces persistently demonstrated that the male obesity prevalence was more than 50% (21).

In general, the overall obesity prevalence among the Armed Forces was below 15%, except for the Saudi Arabia Armed Forces (29%) (26). The lowest overall obesity prevalence was 4.2%, which was recorded in the US Armed Forces between 2008 and 2015 (25). The male obesity prevalence was between 10% and 15%, except for the Greek Armed Forces (4.8%) (32). The highest male obesity prevalence was 25%, which was recorded in the UK Armed Forces (29). However, this figure was the obesity prevalence for personnel aged between 35 to 44 years old. Only two studies provided prevalence for female obesity. The UK Armed Forces female obesity prevalence was 12.9% in 2006 to 2007 (15), which was higher than the US Armed Forces of 8.2% in 2005 (21).

There were four studies conducted among the Navy personnel, with three from the US (19, 37, 38) and one from Malaysia, among the Royal Malaysian Navy (14). The overall overweight and obesity prevalence among the US Navy were between 40% and 50%, and between 10% and 15% respectively. The Royal Malaysian Navy recorded a lower overweight and obesity prevalence with

30% and 7% respectively. Lennon et al. (2015) was the only study that provided the obesity prevalence for male and female Navy personnel with 15.4% and 4.6% respectively (19).

There was only one study involving the Air Force personnel, from the US (31). Compared to the other service branches, the Air Force overweight and obesity prevalence was on the higher side with 54.5% and 18.8% respectively. However, this was only based on a single study. Overall, the estimated prevalence for overweight and obesity were comparable between different service branches (Table 5), except the Air Force.

**Table 6: Estimated prevalence of overweight and obesity for different military service branches**

Service Branch	No. of studies	Estimated Overweight Prevalence			Estimated Obesity Prevalence		
		Overall	Male	Female	Overall	Male	Female
		Army	14	30-50%	40-55%	10-30%	10-20%
Armed Forces	8	40-50%	25-60%	25-30%	5-15%	5-15%	8-13%
Navy	4	30-50%	NA	NA	7-15%	15%*	5%*
Air Force	1	54%*	NA	NA	19%*	NA	NA

NA – Not Available

\* Based on a single study

## Discussion

This systematic review demonstrated that there is an increasing trend in terms of overweight and obesity among the military population. The rates of overweight were higher than the general population while the opposite was observed for the prevalence of obesity. There were variations in the prevalence of overweight and obesity among the military between and within countries, even within the same service branches. This review may be the first to systematically assess the trend and prevalence of overweight /obesity among the military population.

From a total of 27 included studies, approximately 90% of them were published in the last 10 years. Most of the studies were conducted in the Western countries with only three studies from the Asian countries. The prevalence of overweight and obesity in the Asian countries were around 30% and 2% to 5% respectively. These were considered relatively low compared to the Western countries with prevalence harbouring around 40% to 50% for overweight and 10% to 20% for obesity. However, the increment rates of overweight and obesity prevalence were much faster in Asian countries. This was partly due to the increased in the obesogenic environment, which was influenced by the development in the Asian countries. Furthermore, the standard operating procedures and enforcement on obesity differed between countries, including different cut-off used in the administrative regulation of personnel BMI. The lack of studies among the Asian and Middle Eastern countries may have limited these comparisons.

Contrary to the country and regions comparison, the prevalence of overweight and obesity between the service branches did not differ much. The lower prevalence found in the Asian's Army and Navy may not be representative as majority of the studies were from the US and the European countries. Thus, the prevalence of overweight and obesity especially among the Army and the Armed Forces reflected more on the prevalence of the US and the European countries. Only the Army and the Armed Forces have acceptable number of studies and data to allow generalisation of the results. More studies among the Navy and Air Force personnel are needed to enable more meaningful comparisons to be made.

Compared to their respective general population, the military population has a higher prevalence of overweight, but lower prevalence of obesity. The military population also showed a higher increment in the prevalence of overweight. The increment in the prevalence of obesity was comparable between the military and general population. The higher prevalence of overweight among the military personnel may be due to the nature of their physically demanding jobs that predisposed them to develop bigger muscle mass. Overweight personnel may have an advantage in terms of muscular strength, which is very much required for physical jobs such as heavy lifting and load carrying. Meanwhile, there were two possibilities of lower prevalence of obesity among the military personnel. They could have either shed off their fat through routine physical training or those who exceeded the BMI cut-off point were terminated from the service. Thus, it is unlikely to have obese personnel in service.

The key limitation to this systematic review was that the prevalence of overweight and obesity from different studies was measured at different time points. Comparison between countries and military branches could not be conducted at the same time point. However, the available results provided evidence on the military population is experiencing the problem of overweight and obesity and there is an increasing trend observed. Despite these limitations, this review was able to systematically demonstrate the trend and prevalence of overweight and obesity in military population between different countries and regions. These findings may be useful for the policy makers to plan for intervention programs to prevent the consequences of overweight /obesity among the military population such as increased rates of injuries, low work productivity, incurred higher healthcare costs and prematurely discharge from service.

### **Conclusion:**

This systematic review has shown that the military population is not protected from the problems of overweight and obesity despite their physically active work culture. The prevalence is increasing in

all nations lead by the Western countries. However, the Asian countries are catching up fast. Intervention programs or policies should be planned and implemented to address this issue.

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