BODY MASS INDEX LIMITATION OF OVERWEIGHT AND OBESITY IN CZECH MILITARY PERSONNEL

Blanka Kupsová[1], Vladimír Pavlík[1], Jana Fajfrová[1, 3], Václav Šafka[1], Petr Lašák[1], Jan M. Horáček[1, 2]
[1]Department of Military Internal Medicine and Military Hygiene, Military Faculty of Medicine, University of Defence, Hradec Králové, Czech Republic
[2]Department of Internal Medicine IV – Haematology, University Hospital Hradec Králové and Faculty of Medicine, Charles University in Hradec Králové, Hradec Králové, Czech Republic
[3]Department of Occupational Medicine, University Hospital Hradec Králové and Faculty of Medicine, Charles University in Hradec Králové, Hradec Králové, Czech Republic

SUMMARY

Objectives: The first aim of this cross-sectional study was to reveal the prevalence of overweight and obesity among Czech military personnel (CMP). The second aim was to compare accuracy of the body mass index (BMI) classification with the body fat percentage (BF%), waist circumference (WC), and visceral fat area (VFA). BMI is a commonly used method to assess obesity, but its accuracy in reflecting body composition, especially in physically fit individuals, has been questioned.

Methods: Data were collected from six military units in the Czech Republic. Soldiers underwent anthropometric assessments including height, weight, WC, BF%, and VFA using the bioelectrical impedance method (BIA).

Results: The study group consisted of 446 soldiers (337 males, 109 females). The prevalence of obesity in Czech soldiers regardless of gender was 18%–20% according to BF% and 13%–16% according to WC. There were almost one fifth of obese males and more than 5% of females with BMI ≥ 30. The risk level of VFA was observed in 24% of male a 34% of female soldiers. In male soldiers there was a high rate (43%) of false positives according to BMI (BMI ≥ 25, BF% < 20), on the other hand, a certain part (18%) of female soldiers was classified as false negative according to BMI (BMI < 25, BF% ≥ 28). When overweight and obesity were assessed by WC and BMI, significant false positives (56%) were found in male soldiers (BMI ≥ 25, WC < 94). When obesity was evaluated using VFA and BMI, a certain rate of false negatives (30%) was found in female soldiers (BMI < 25, VFA ≥ 100).

Conclusion: Through an analysis we explored the limitations of BMI, and we propose an alternative method (measurement of BF%, VFA using BIA) for a more accurate assessment of body composition in this specific population.

Key words: body mass index, body composition, military personnel, obesity, visceral fat

Address for correspondence: V. Pavlík, Department of Military Internal Medicine and Military Hygiene, Military Faculty of Medicine, University of Defence, Třebešská 1575, 500 01 Hradec Králové, Czech Republic. E-mail: vladimir.pavlik@unob.cz

https://doi.org/10.21101/cejph.a8529

INTRODUCTION

Obesity is a complex chronic disease that, if left untreated, significantly increases the risk of development of type 2 diabetes, cancer and cardiovascular diseases, leads to respiratory insufficiency and other multi-organ impairments and multi-system disorders, including musculoskeletal overload. The consequences of obesity impair quality of life, reduce work capacity, and increase morbidity and mortality. There is also a greater risk for injury in active obese population (1, 2). Systematic reviews agree that obesity absorbs a huge amount of healthcare resources (3, 4).

According to the survey conducted by the Czech Statistical Office in 2022, 48.6% of adult men and 35.7% of adult women are overweight (BMI 25–30 kg/m^2); obesity (BMI ≥ 30 kg/m^2) was found in 21% of males and 18.4% of females. The average body mass index (BMI) has increased since 2017 from 25.2 to 26.2 kg/m^2 (5). According to the World Health Organization (WHO) European Regional Obesity Report 2022, the Czech Republic ranks 7th among European countries in the prevalence of overweight and obesity (62% of the Czech population) (6).

BMI is a widely used tool for assessing overweight and obesity, but its reliability, particularly in physically fit individuals such as military personnel, has been questioned. BMI cannot distinguish between lean body mass and fat mass, so individuals with a greater muscle mass may be misclassified as overweight or obese when using BMI (7, 8). On the other hand, BMI may underestimate obesity in some individuals (particularly in women) compared to overall body fat percentage (9).

The aims of this study were to reveal the prevalence of overweight and obesity among Czech military personnel (CMP) and to investigate the accuracy of BMI in identifying overweight and obesity compared to body fat percentage (BF%), waist circumference (WC), and visceral fat area (VFA).

MATERIALS AND METHODS

This research was conducted as a non-experimental cross-sectional study, using a sample of Czech professional soldiers. Given that nearly 14% of soldiers in the Czech Armed Forces in 2023 were women, our research was also interested in their body composition. All participants were whites. Involvement in the study was voluntary. They were all informed about the research before they agreed to participate in the study by providing an oral informed consent. The study focused on six selected military units (2 – logistics units, 2 – units of air personnel including ground personnel, 1 – Rapid Reaction Forces Unit, 1 – Radiation and Chemical Defence Regiment). Data for this research were collected between June 2023 and June 2024. All measurements were performed during the visit of the military unit.

Anthropometric data including height, weight, BMI, BF%, and WC were assessed by trained investigators. Subjects were weighed in minimal clothing and height was measured using a portable stadiometer combined with weighing scale (Inbody Co., Ltd, Seoul, Korea). BMI was calculated using the standard formula – weight (kg) divided by height squared (m^2). WC and hip circumference were determined using a tailor's tape measure in accordance with recommendations of current obesity guidelines (6). The waist-hip ratio was calculated. BF% was assessed using bioelectrical impedance analysis (BIA), the body water analyser 2.0 machine (Inbody Co., Ltd, Seoul, Korea) using the 16-point clamp electrodes positioned on the wrist and ankle bones (10). Examination was performed in lying position. The underlying principle of BIA involves the measurement of the body's electrical impedance, which is the resistance to the flow of an alternating electrical current. BIA correlates well with dual-energy X-ray absorptiometry that is the reference standard for assessing body composition (11). Other parameters from BIA analysis such as total body water (kg), fat mass (kg), fat free mass (kg), and skeletal mass (kg) were evaluated.

Male and female soldiers were evaluated separately because of different limits for BF% and WC. Participants were classified into three groups according to BMI – normal weight (BMI 18.5–24.9), overweight (BMI 25–29.9) and obesity (BMI ≥ 30), and compared to normal BF% (males/females BF% < 20/28), overweight (males BF% 20–25, females BF% 28–33) and obesity (males/females BF% ≥ 25/33). According to WC, three groups were assigned – males: < 94 cm, 94 to 102 cm and ≥ 102 cm, females: < 80 cm, 80–88 cm and ≥ 88 cm. The value of visceral fat area (risky over 100) was also taken into consideration because it is a critical risk factor for cardiovascular complication (12).

Table 1. Descriptive data for male and female soldiers (N = 446)

	Males n = 377 Mean (SD)	Females n = 109 Mean (SD)
Age (years)	39.0 (8.7)	41.2 (10.2)
Weight (kg)	88.0 (13.6)	69.3 (11.,9)
Height (cm)	178.8 (7.7)	166.5 (6.5)
WC (cm)	90.5 (11.0)	79.1 (9.7)
BMI (kg/m²)	27.4 (3.5)	24.9 (3.7)
BF (%)	19.1 (7.0)	27.4 (3.5)
VFA (cm²)	78.2 (40.1)	87.3 (42.0)

WC – waist circumference; BMI – body mass index; BF – body fat; VFA – visceral fat area

The results for quantitative variables were presented in the form of descriptive statistics (mean, standard deviation, median). For comparative analysis the Kruskal-Wallis test was used. A statistical significance value of $p < 0.05$ was assumed, and the normality of distributions was checked using the Shapiro-Wilk test.

RESULTS

There were 446 participants (337 male soldiers and 109 female soldiers) in our cross-sectional study. Description of the sample is shown in Table 1.

The prevalence of overweight and obesity in surveyed soldiers differed according to evaluation criteria (Fig. 1). The prevalence of obesity in male soldiers was 19.3/18.4/13.3% according to BMI/BF%/WC, in female soldiers then 5.5/20.2/15.6% according to

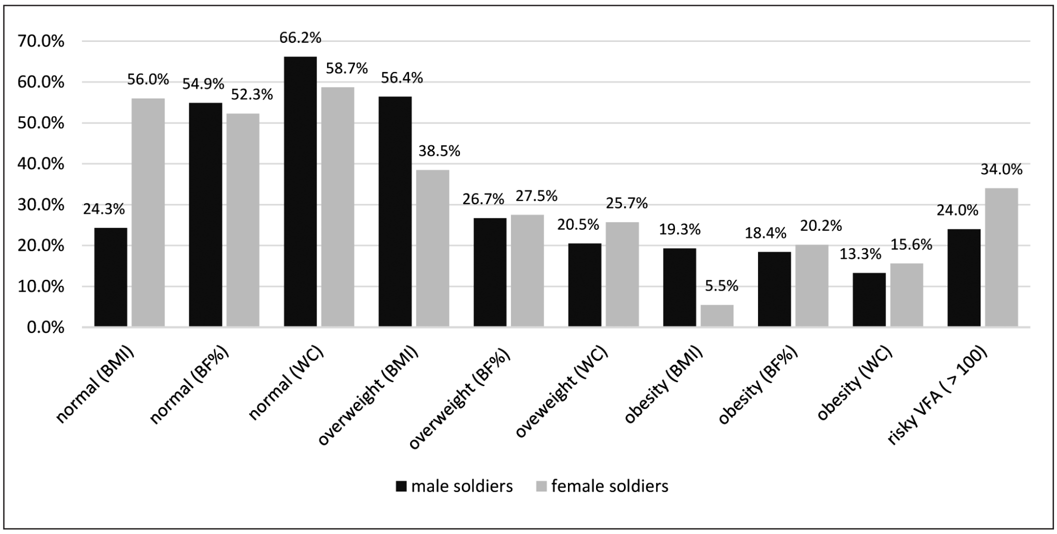

Fig. 1. Prevalence of overweight and obesity.

BMI – body mass index; BF – body fat; WC – waist circumference; VFA – visceral fat area

BMI/BF%/WC. The risk level of VFA was observed in 24% of male a 34% of female soldiers.

Rates of false positives (FP) – normal BF%, WC, VFA but overweight/obesity according to BMI, and false negatives (FN) – normal BMI but overweight/obesity according to BF%, WC, VFA, for comparing BF%, WC and VFA standards to the BMI-based categories are shown in Table 2 and Table 3.

According to BMI (FP), 43% and 56% of male soldiers with normal weight defined by BF% and WC standards were identified as overweight/obese. On the other hand, approximately 18% and 16% of BF%- and WC-defined overweight/obese female soldiers were misclassified as normal weight using BMI (FN).

When compared rates of obesity, 35% and 15% of nonobese male soldiers defined by BF% and VFA standards were identified as FP. On the other hand, 16% and 30% of BF%- and VFA-defined obese female soldiers were identified as FN.

Table 2. *Presentation of false positive and false negative results according to BMI and BF in overweight and obese soldiers*

	Overweight and obesity (BMI ≥ 25)		
Males	BF% ≥ 20	BF% < 20	
BMI ≥ 25	145	110	FP 110/255 (43%)
BMI < 25	7	75	FN 7/82 (8%)
Females	BF% ≥ 28	BF% < 28	
BMI ≥ 25	41	7	FP 7/48 (15%)
BMI < 25	11	50	FN 11/61 (18%)
Males	WC ≥ 94 cm	WC < 94cm	
BMI ≥ 25	112	143	FP 143/255 (56%)
BMI < 25	2	80	FN 2/82 (2%)
Females	WC ≥ 80 cm	WC < 80	
BMI ≥ 25	39	9	FP 9/48 (19%)
BMI < 25	10	51	FN 10/61 (16%)

BMI – body mass index; BF% – body fat percentage; WC – waist circumference; FP – false positive; FN – false negative

Table 3. *Presentation of false positive and false negative results according to BMI and BF in obese soldiers*

	Obesity (BMI ≥ 30)		
Males	BF% ≥ 25	BF% < 25	
BMI ≥ 30	39	26	FP 26/75 (35%)
BMI < 30	23	249	FN 23/272 (8%)
Females	BF% ≥ 33	BF% < 33	
BMI ≥ 30	6	0	FP 0/6 (0%)
BMI < 30	16	87	FN 16/103 (16%)
Males	VFA ≥ 100	VFA < 100	
BMI ≥ 30	55	10	FP 10/65 (15%)
BMI < 30	26	246	FN 26/272 (10%)
Females	VFA ≥ 100	VFA < 100	
BMI ≥ 30	6	0	FP 0/6 (0%)
BMI < 30	31	72	FN 31/103 (30%)

BMI – body mass index; BF% – body fat percentage; VFA – visceral fat area; FP – false positive; FN – false negative

Lower rates of overweight and obesity according to BF% compared to BMI (FP) are probably due to a higher muscle mass in male soldiers than in general population (so called muscular obesity). On the other hand, we found that BMI-based obesity was likely underestimated (FN) in a certain number of female soldiers.

Main demographic variables of male soldiers are presented in Table 4 (subjects divided according to BMI) and Table 5 (subjects divided according to BF%). The obese personnel were significantly older compared to overweight and normal weight subjects. Soldiers with diagnosed obesity according to BMI had significantly higher scores in all body composition parameters than those with normal values. The mean body fat content in obese subjects was 27.5% (29.9%) vs. 13.4% (13.9%) in normal weight soldiers according to BMI (BF%). The comparative analysis of total body water content, lean body mass, skeletal muscle mass in groups of soldiers divided according to BF% did not show any significance ($p > 0.05$) (Table 5).

Correlation of important body characteristics of male soldiers is shown in Table 6. The highest positive correlation is between BF% and VFA, BMI and VFA. The highest negative correlation is between BF% and skeletal muscle mass (SMM), and VFA and SMM. No importance between other characteristics was found.

DISCUSSION

The purpose of this study was to examine the accuracy of BMI when defining obesity and overweight status and compare it with BF%, VFA (bioimpedance analysis) and WC standards. The strength of this study includes the use of BIA-body composition measurements in military personnel (male and female soldiers). There was a limitation in lower number of females.

The prevalence of obesity according to BMI in Czech soldiers in the year 2009 was 14.3% in males and 16.1% in females, which differs significantly from our results. On the other hand, the results support the hypothesis that male individuals with normal body fat percentage and increased muscularity are also categorized as overweight or even obese according to BMI which is consistent with our findings (13).

According to Jitnarin et al. study of normal and overweight US firefighters, comparing BMI categories to the analogous BF% categories resulted in low rates of false positives (10%) and median rates of false negatives (22%). However, using WC as the standard resulted in the opposite situation, with high rates of false positives (63%) and very low rates of false negatives (5%) (8). Additionally, based on their study of obesity in US firefighters, approximately 33% and 15% of BF%- and WC-defined obese participants were misclassified as non-obese using BMI (i.e., false negatives). On the other hand, 8% and 9% of non-obese participants defined by BF% and WC standards were identified as obese using BMI (i.e., false positives) (14).

Obesity prevalence in Russian firefighters was 22% for BMI ≥30, 60% for BF% ≥25 and 28% for WC >102 cm. False positive rates for BMI-based obesity were low, with 3% and 6% of non-obese participants defined by BF% and WC standards but misidentified as obese using BMI. However, 65% of BF%-defined obese participants and 36% of WC-defined obese participants were misclassified as non-obese using BMI (i.e., false negatives) (15). Similar research was carried out among Russian police officers.

Table 4. *Results of anthropometric measurements and body composition analysis of subjects divided according to BMI (N = 377)*

Male soldiers	Body mass index: Normal <25 (n = 82)			Overweight 25–30 (n = 190)			Obese >30 (n = 65)			p-value
	Mean (SD)	Median	Min–max	Mean (SD)	Median	Min–max	Mean (SD)	Median	Min–max	
Age (years)	36.4 (9.2)	36	20–58	38.6 (8.1)	40	20–57	43.5 (8.4)	45.0	24–60	**<0.001**
Height (cm)	179.0 (6,4)	179.4	161.8–193.3	179.0 (6.3)	178.9	163.6–198.0	179.0 (5.7)	178.7	165.7–191.5	0.958
Weight (kg)	75.5 (6.5)	75.8	59.6–93.1	87.4 (7.5)	87.0	70.1–112.5	104.6 (11.8)	103.4	85.4–159.1	**<0.001**
BMI (kg/m^2)	23.5 (1.2)	23.9	20.3–24.9	27.3 (1.4)	27.1	25.0–29.9	32.6 (2.9)	31.5	30.0–44.2	**<0.001**
TBW (kg)	47.9 (4.6)	48.1	38.3–60.6	52.2 (5.5)	51.7	42.5–72.1	55.4 (5.3)	54.7	44.5–70.5	**<0.001**
FM (kg)	10.2 (3.6)	9.9	2.1–0.1	16.3 (5.0)	16.5	3.9–29.7	29.1 (9.0)	27.8	15.8–64.7	**<0.001**
BF (%)	13.4 (4.5)	12.9	3.0–24.6	18.6 (5.3)	18.5	4.3–31.0	27.5 (5.8)	27.2	15.1–44.0	**<0.001**
FFM (kg)	65.3 (6.2)	65.3	51.9–82.5	71.1 (7.5)	70.5	57.6–98.4	75.5 (7.2)	74.1	60.5–95.5	**<0.001**
SMM (kg)	37.0 (3.7)	36.6	28.5–46.4	40.4 (4.5)	39.9	31.9–56.3	42.8 (4.2)	42.3	34.2–53.3	**<0.001**
WC (cm)	81.1 (6.2)	81.0	56.2–96.0	90.4 (6.0)	90.0	8.5–107.0	104.0 (9.5)	103.0	76.3–136.0	**<0.001**
HC (cm)	96.1 (3.7)	96.4	84.8–103.0	102.6 (4.4)	102.8	93.2–120.6	110.4 (6.7)	109.7	92.3–137.0	**<0.001**
WHR	0.8 (0.0)	0.8	0.7–1.0	0.9 (0.1)	0.9	0.8–1.0	1.0 (0.1)	1.0	0.9–1.2	**<0.001**
VFA (cm^2)	43.6 (19.1)	42.4	5.0–91.6	74.1 (24.4)	75.7	14.8–130.8	133.9 (38.8)	127.9	74.7–266.5	**<0.001**

SD – standard deviation; BMI – body mass index; TBW – total body water; FM – fat mass; BF – body fat; FFM – fat free mass; SMM – skeletal muscle mass; WC – waist circumference; HC – hip circumference; WHR – waist-hip ratio; VFA – visceral fat area; p – Kruskal-Wallis test
Numbers in bold indicate statistically significant values.

Table 5. *Results of anthropometric measurements and body composition analysis of subjects divided according to body fat percentage (N = 377)*

Male soldiers	Body fat percentage: Normal <20 (n = 185)			Overweight 20–25 (n = 90)			Obese >25 (n = 62)			p-value
	Mean (SD)	Median	Min–max	Mean (SD)	Median	Min–max	Mean (SD)	Median	Min–max	
Age (years)	35.6 (8.2)	34	20–58	41.5 (7.1)	42	25–58	45.4 (7.4)	46	25–60	**<0.001**
Height (cm)	179.6 (6.5)	180.0	161.8–198.0	179.0 (5.9)	178.8	165.6–192.6	177.2 (5.3)	176.6	165.7–189.7	0.015
Weight (kg)	82.6 (9.9)	81.3	59.6–112.5	89.9 (9.5)	88.8	68.0–113.1	100.3 (14.3)	97.0	80.1–159.1	**<0.001**
BMI (kg/m^2)	25.6 (2.2)	25.6	20.3–31.3	28.0 (2.3)	27.9	23.5–33.5	31.9 (3.5)	31.2	26.9–44.2	**<0.001**
TBW (kg)	52.1 (6.1)	51.7	38.3–72.1	51.4 (5.4)	51.2	38.4–65.0	51.4 (5.3)	50.5	42.5–70.5	0.513
FM (kg)	11.6 (3.5)	11.9	2.1–19.6	19.9 (2.6)	19.5	15.7–27.1	30.4 (8.3)	28.6	20.3–64.7	**<0.001**
BF (%)	13.9 (3.6)	14.5	3.0–19.9	22.1 (1.5)	21.8	20.0–24.9	29.9 (3.8)	29.6	25.0–44.0	**<0.001**
FFM (kg)	71.0 (8.3)	70.5	51.9–98.4	70.0 (7.4)	69.7	52.1–88.5	69.9 (7.3)	68.9	57.7–95.5	0.452
SMM (kg)	40.5 (4.9)	39.9	28.5–56.3	39.6 (4.4)	39.3	28.9–49.9	39.5 (4.1)	38.9	31.9–53.3	0.200
WC (cm)	85.1 (6.7)	84.6	56.2–107.0	93.5 (6.5)	93.0	80.2–110.0	103.9 (9.5)	102.2	76.3–136.0	**<0.001**
HC (cm)	99.7 (5.2)	99.3	84.8–120.6	103.9 (5.3)	103.9	92.0–116.0	109.0 (7.2)	108.0	92.3–137.0	**<0.001**
WHR	0.8 (0.0)	0.9	0.7–1.0	0.9 (0.0)	0.9	0.8–1.0	1.0 (0.1)	1.0	0.9–1.2	**<0.001**
VFA (cm^2)	51.3 (19.4)	52.9	5.0–95.2	91.9 (13.8)	90.3	65.1–132.9	138.4 (36.2)	129.8	87.6–266.5	**<0.001**

SD – standard deviation; BMI – body mass index; TBW – total body water; FM – fat mass; BF – body fat; FFM – fat free mass; SMM – skeletal muscle mass; WC – waist circumference; HC – hip circumference; WHR – waist-hip ratio; VFA – visceral fat area; p – Kruskal-Wallis test
Numbers in bold indicate statistically significant values.

BMI-defined obesity rates were 4.6%, WC-defined obesity rates were similar to BMI (3.3%), but BF%-defined obesity rates were much higher (22.2%). BMI alone was not a particularly accurate method for classifying the weight status among Russian police officers (16).

In police trainees in Serbia the prevalence of obesity using BMI classification was low (2.9%), while the prevalence of overweight was higher 48.5%. On the other hand, the prevalence of obesity using BF% classification was 12.6%. These results reflect how

Table 6. *Correlation between important body characteristics in male soldiers (N = 377)*

Male soldiers	BMI	BF%	SMM	LMT%	WHR	VFA	WC
BMI	1	0.750	-0.701	−0.146	0.403	0.848	0.736
BF%	0.750	1	−0.993	−0.023	0.538	0.949	0.714
SMM	−0.701	−0.993	1	0.016	−0.530	−0.937	−0.685
LMT%	−0.146	−0.023	0.016	1	0.107	−0.054	−0.060
WHR	0.403	0.538	−0.530	0.107	1	0.512	0.850
VFA	0.848	0.949	−0.937	−0.054	0.512	1	0.775
WC	0.736	0.714	−0.685	−0.060	0.850	0.775	1

BMI – body mass index; BF% – body fat percentage; SMM – skeletal muscle mass; LMT% – lean mass of trunk percentage; WHR – waist-hip ratio; VFA – visceral fat area; WC – waist circumference

BMI can misclassify obese subjects as overweight or even normal weight, while those with a greater muscle mass were categorized as overweight (17). The evaluation of body fat was estimated from BMI and BIA in Belgian male military candidates; 6.5% of participants were misclassified as false negative (BMI ≥ 25, BF% < 21), on the other hand, 10.5% of participants as false positive (BMI < 25, BF% ≥ 21) (18). In Polish military flying personnel the prevalence of overweight and obesity was diagnosed in 63.5% of soldiers using BMI and in 52.5% using BF%; abdominal obesity was found in almost half of the surveyed soldiers according to WC (47%). Low rates of obesity and overweight according to BF% compared to BMI were revealed, likely due to so-called muscular overweight (19).

In the study of US Army soldiers, 83% of personnel were correctly identified using the age adjusted BMI thresholds as meeting or exceeding the Army body fat standards. Sensitivity of 77% and specificity of 100% were calculated when using the age adjusted BMI thresholds (20). According to Foulis et al. study of US Army trainees, the threshold of clinical overweight (BMI 25) has low precision in classifying a high body fat percentage in healthy men (BF% > 20) or women (BF% > 30) (21). Those individuals in the lower end of BMI represent a special subset of the emerging digital generation ‘skinny fat’ (metabolically obese normal weight), with recruits who may have a normal relative fat mass and therefore an even lower fat-free mass than expected (22).

Ode et al. compared US college athletes and nonathletes, 67% of male and 31% of female athletes fell within the false positive quadrant (overweight and normal fat percentage). In addition, 25% of male and only 7% of female nonathletes fell within the FP quadrant. There were no false negatives in the male and female athlete groups, only a small proportion of overfat male nonathletes were classified as FN, but 44% of female nonathletes were FN (23).

In the study of the US Navy personnel, 81% of the total sample were classified as overweight (44%) or obese (37%) by BMI and 74% as obese by BF%. Using BMI, 97% of the subjects were correctly identified as non-obese (good specificity), but only 36% of them were correctly identified as obese (poor sensitivity). Lean mass, fat mass and BF% showed a good correlation with BMI (24). The research in US military officers shows similar results where 21.4% of males were classified as obese using BMI ≥ 30 while the BF% ≥ 25 revealed 30.1% of participants being obese. Only 9.4% of females were found obese according to BMI (BMI ≥ 30) while 69.7% of participants were found obese using BF% (BF% > 30). So, obesity was underestimated using BMI (25).

According to the physical profile of US Air Force special warfare trainees, the mean BMI falls within the overweight range, but body fat analysis indicates that most of the candidates do not have excessive body fat levels (26). Similar findings were presented in very fit men measured at TheFitExpo Anaheim 2015 event. The mean BMI in these men was 25.9 (overweight), however, the average BF% was only 16.8% (in healthy weight range). On the other hand, in women there was a higher correlation between BF% and BMI than in men (27).

To sum up, the conclusions of some studies are consistent with our findings (13, 17, 19, 23, 26, 27). On the other hand, the underestimation of obesity prevalence by BMI was found in other studies (8, 14–16, 25).

CONCLUSION

Our results are expected, and multiple factors must be considered at once when assessing body composition. The assessment of body composition using BMI has its limitations. BMI may misclassify individuals with a higher muscle mass as obese, particularly in male soldiers where physical fitness is a crucial aspect of the job. On the other hand, BMI may underestimate obesity, especially in females. BMI does not differentiate between visceral and subcutaneous fat, which is vital in understanding the health risks associated with obesity. The study contributes to the broader discussion on the limitations of BMI, particularly in physically active populations, and underscores the importance of tailored health assessment approaches for military readiness.

Acknowledgement

The work was supported by the Ministry of Defence of the Czech Republic “Long Term Organization Development Plan 1011” – Clinical Disciplines II of the Military Faculty of Medicine Hradec Králové, University of Defence, Czech Republic (Project No: DZRO-FVZ22-KLINIKA II), and by the Ministry of Defence of the Czech Republic “Strengthening the physical and mental resilience of soldiers for combat operations deployment” – OY – Ambitions (Project No: OYUOB20240006).

Conflicts of Interest

None declared

REFERENCES

1. Jahnke SA, Poston WS, Haddock CK, Jitnarin N. Obesity and incident injury among career firefighters in the central United States. Obesity (Silver Spring). 2013 Aug;21(8):1505-8.
2. Taanila H, Suni JH, Kannus P, Pihlajamäki H, Ruohola JP, Viskari J, et al. Risk factors of acute and overuse musculoskeletal injuries among young conscripts: a population-based cohort study. BMC Musculoskelet Disord. 2015 May 1;16:104. doi: 10.1186/s12891-015-0557-7.
3. Specchia ML, Veneziano MA, Cadeddu C, Ferriero AM, Mancuso A, Ianuale C, et al. Economic impact of adult obesity on health systems: a systematic review. Eur J Public Health. 2015;25(2):255-62.
4. Tremmel M, Gerdtham UG, Nilsson PM, Saha S. Economic burden of obesity: a systematic literature review. Int J Environ Res Public Health. 2017;14(4):435. doi: 10.3390/ijerph14040435.

5. Měřínská S. [Living conditions of Czech households] [Internet]. Prague: Czech Statistical Office; 2023 [cited 2023 Feb 02]. Available from: https://csu.gov.cz/docs/107508/f40a6cc2-30ef-711a-8db1-f8b3c7f68ab6/csu_tk_silc_2022_prezentace.pdf. Czech.
6. World Health Organization. WHO European Regional Obesity Report 2022 [Internet]. Copenhagen: WHO Regional Office for Europe; 2022 [cited 2023 Feb 02]. Available from: https://iris.who.int/bitstream/handle/10665/353747/9789289057738-eng.pdf?sequence=1.
7. Alasagheirin MH, Clark MK, Ramey SL, Grueskin EF. Body mass index misclassification of obesity among community police officers. AAOHN J. 2011;59(11):469-75.
8. Jitnarin N, Poston WSC, Haddock CK, Jahnke S, Tuley BC. Accuracy of body mass index–defined overweight in fire fighters. Occup Med (Lond). 2013;63(3):227-30.
9. Jahnke SA, Poston WS, Haddock CK, Jitnarin N, Hyder ML, Horvath C. The health of women in the US fire service. BMC Womens Health. 2012;12:39. doi: 10.1186/1472-6874-12-39.
10. InBody USA. BWA 2,0 Body Water Analyzer [Internet]. InBody USA [cited 2023 Dec 18]. Available from: https://inbodyusa.com/products/bwa2-0/.
11. Combest TM, Khan J, Tufano JJ, Lane M, Watson NL, Altom KR, et al. Comparison of four body composition methods: circumference measurements, eight-point bioelectrical impedance analysis up to 500 and 1000 kHz to dual-energy X-ray absorptiometry to measure body fat percentage. Mil Med. 2025 Feb 27;190(3-4):e642-8.
12. Jeon HH, Lee YK, Kim DH, Pak H, Shin SY, Seo JH. Risk for metabolic syndrome in the population with visceral fat area measured by bioelectrical impedance analysis. Korean J Intern Med. 2021;36(1):97-105.
13. Fajfrová J, Pavlík V, Psutka J, Husarová M, Krutišová P, Fajfr M. Prevalence of overweight and obesity in professional soldiers of the Czech Army over an 11-year period. Vojnosanit Pregl. 2016;73(5):422-8.
14. Jitnarin N, Poston WS, Haddock CK, Jahnke SA, Day RS. Accuracy of Body Mass Index-defined obesity status in US firefighters. Saf Health Work. 2014;5(3):161-4.
15. Gurevich KG, Poston WS, Anders B, Ivkina MA, Archangelskaya A, Jitnarin N, et al. Obesity prevalence and accuracy of BMI-defined obesity in Russian firefighters. Occup Med (Lond). 2017;67(1):61-3.
16. Heinrich KM, Gurevich KG, Arkhangelskaia AN, Karazhelyaskov OP, Poston WSC. Despite low obesity rates, Body Mass Index under-estimated obesity among Russian police officers when compared to body fat percentage. Int J Environ Res Public Health. 2020;17(6): 1937. doi: 10.3390/ijerph17061937.
17. Stojković M, Heinrich KM, Čvorović A, Jeknić V, Greco G, Kukić F. Accuracy of Body Mass Index and obesity status in police trainees. Eur J Investig Health Psychol Educ. 2022;12(1):42-9.
18. Mullie P, Vansant G, Hulens M, Clarys P, Degrave E. Evaluation of body fat estimated from body mass index and impedance in Belgian male military candidates: comparing two methods for estimating body composition. Mil Med. 2008;173(3):266-70.
19. Gaździńska A, Gaździński S, Jagielski P, Kler P. Body composition and cardiovascular risk: a study of Polish military flying personnel. Metabolites. 2023;13(10):1102. doi: 10.3390/metabo13101102.
20. Grier T, Canham-Chervak M, Sharp M, Jones BH. Does body mass index misclassify physically active young men. Prev Med Rep. 2015;11(2):483-7.
21. Foulis SA, Hughes JM, Spiering BA, Walker LA, Guerriere KI, Taylor KM, et al. US Army basic combat training alters the relationship between body mass index and per cent body fat. BMJ Mil Health. 2023;169(4):340-5.
22. Foulis SA, Hughes JM, Friedl KE. New concerns about military recruits with metabolic obesity but normal weight ("skinny fat"). Obesity (Silver Spring). 2020;28(2):223. doi: 10.1002/oby.22724.
23. Ode JJ, Pivarnik JM, Reeves MJ, Knous JL. Body mass index as a predictor of percent fat in college athletes and nonathletes. Med Sci Sports Exerc. 2007;39(3):403-9.
24. Gasier HG, Hughes LM, Young CR, Richardson AM. Comparison of body composition assessed by dual-energy X-ray absorptiometry and BMI in current and former U.S. Navy service members. PLoS One. 2015;10(7):e0132157. doi: 10.1371/journal.pone.0132157.
25. Hollerbach BS, Haddock CK, Kukić F, Poston WSC, Jitnarin N, Jahnke SA, et al. Comparisons of baseline obesity prevalence and its association with perceived health and physical performance in military officers. Biology (Basel). 2022;11(12):1789. doi: 10.3390/biology11121789.
26. Feeney KA, Melton BF, Bland HW, Ryan GA, Butler CR. Physical profile of Air Force special warfare trainees. Int J Exerc Sci. 2023;16(4):924-31.
27. InBody USA. We tested 402 people at TheFitExpo [Internet]. InBody USA; 2015 [cited 2023 Dec 12]. Available from: https://inbodyusa.com/blogs/inbodyblog/41937409-we-tested-402-people-at-thefitexpo-heres-what-we-found/.

Received January 13, 2025
Accepted in revised form May 29, 2025