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ORIGINAL ARTICLE

PSYCHOLOGICAL BURDEN AND METABOLIC SYNDROME IN PROFESSIONAL SOLDIERS

Pavla Krutisova [1]✉, Vladimír Pavlik [2], Eva Cermakova [3], Jana Fajfrova [4], Dana Fialova [5]

[1] Department of Emergency Medicine and Military General Medicine, Military Faculty of Medicine, University of Defence, Czech Republic
[2] Department of Military Internal Medicine and Military Hygiene, Military Faculty of Medicine, University of Defence, Czech Republic
[3] Department of Medical Biophysics, Faculty of Medicine in Hradec Kralove, Charles University, Czech Republic
[4] Department of Public Health Protection and Pharmacy, Divison of Administrative Activities, Section of Military Health, Czech Republic
[5] University Education Department in Hradec Kralove, Language Centre, University of Defence, Czech Republic

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Summary

The aim of the study is to investigate whether the mental stress resulting from the assignment of military professionals affects the parameters of metabolic syndrome (MetS) as a significant risk factor for cardiovascular diseases.

The study retrospectively analyses the data obtained during extended annual preventive examinations of professional soldiers in 2012-2016. The dataset was divided into two cohorts. The first "performance" cohort included soldiers from combat units and paratroopers (aiborne). The second cohort consisted of "others", i.e. soldiers from non-combat units or airborne. The psychological burden was determined by the soldiers' assignment to a combat or airborne units.

In the years 2012-2016, almost all compared parameters were better in the "performance" group. Exceptions were a higher prevalence of overweight (according to body mass index) and sporadically higher glycaemia and alanine aminotrasferase (ALT) levels. When comparing years 2012 and 2016 of the "performace" group, statistically significant better values prevailed in relation to the MetS in 2016. The exceptions were ALT and uric acid levels.

The outcome of this study suggests a better status of MetS risk factors and MetS-related factors in the "performance" cohort, and psychological stress did not augment MetS manifestations in these professionals. This study has confirmed the necessity of waist circumference measurement to eliminate overestimation of obesity in individuals with developed musculature. To confirm the hepatic origin of ALT, the medical history should include an inquiry about exercise habits. Subsequently, the effect of chronic stress may also be considered for higher liver enzymes. Screening for hypercholesterolaemia and hyperuricaemia has important clinical relevance for the prevention of cardiovascular diseases in younger population, particularly in those aged <45 years.

✉ University of Defence, Military Faculty of Medicine, Department of Emergency Medicine and Military General Medicine, Třebešská 1575, 500 01 Hradec Králové, Czech Republic
pavla.krutisova@unob.cz

The gained knowledge could be used for a more thorough search for vulnerable individuals and the timely initiation of preventive measures, including improving psychological resilience and possible early displacement.

Key words: soldier; stress; burden; metabolic syndrome

Introduction

Cardiovascular disease (CVD) or obesity and related metabolic disorders represent a global health problem, and soldiers are no exception. CVD remains the main cause of death worldwide and the most common cause of death in both genders (36.5% of all deaths in men and 43.1% in women) in the Czech Republic in 2020 (1). Basic modifiable risk factors (RF) of CVD include components of the metabolic syndrome (MetS), smoking, including exposure to tobacco smoke, psychosocial stress, atherogenic diet, low physical activity, and systemic inflammatory diseases. Cardiovascular (CV) risk intervention should be shifted to lower age categories because the duration of exposure to risk factors determines the prognosis of patients as significantly as the rate of their increase. The way to reduce the socio-economic burden of the Ministry of Defense or the soldier as such consists in the early treatment of all CVD risk factors, including MetS. Untreated MetS is significantly associated with an increased risk of developing diabetes and cardiovascular disease (CVD), especially ischemic heart disease. In this context, it is important to recall primary prevention and risk modifiers such as psychosocial stress, obstructive sleep apnea syndrome, chronic inflammatory disease, and migraine with aura (2).

MetS is a combination of several risk factors, such as abdominal obesity, insulin resistance, hyperinsulinaemia, elevated blood pressure, and dyslipidaemia which amplify each other. As the measurement of insulin in the blood is difficult for large-scale screening, hence the measurement of this parameter is not part of the criteria. Waist circumference is used instead because it is strongly correlated with insulin resistance (3).

In the Czech Republic, the so-called "harmonized" definition of MetS based on the National Cholesterol Education Program – Adult Treatment Panel III (NCEP ATP III, 2001) is currently used – the presence of three or more of the five risk factors listed means the presence of MetS:

- waist circumference for abdominal obesity (selected for the Czech population): men >94 cm, women >80 cm
- triglycerides (TG) ≥1.7 mmol/l or hypolipidemic therapy
- high density lipoproteins (HDL): men <1.0 mmol/l, women <1.3 mmol/l or hypolipidemic therapy
- blood pressure (BP) ≥130/ ≥85 mm Hg or antihypertensive therapy
- fasting blood glucose ≥5.6 mmol/l or impaired glucose tolerance or diabetes mellitus (DM) type 2 or treatment with antidiabetic drugs

Although it is not clear whether the MetS can be treated as a separate nosological entity, research is gradually revealing its pathogenesis and possible therapeutic targets, such as the treatment of obesity and insulin resistance (3).

A military professional is exposed to stress, harmful environmental factors (climatic conditions), lack of sleep, physical exhaustion, and limited food choices, especially during military training exercises or military missions (4, 5). Studies have shown a high incidence of overweight or obesity among soldiers worldwide. Soldiers meeting the obesity criteria (according to body mass index) make up 8% of the US Army (6), 12% of the British Army (7), 13% of the Iranian Army (8), 10% of the French Army (9) and 6% of the Polish Air (10). A higher percentage of soldiers with excess body weight was found in the Saudi Arabian army, where obesity was diagnosed in 44% of soldiers (11, 12). Acute stress response prepares an individual to cope with uncertainties and threats, but if this acute response is prolonged, it can induce changes in the perception of the body, environment or time, cognition and memory (13). In addition, long-term stress has been proven to impair memory, special abilities, performance and reliability (14). It can also trigger post-traumatic stress syndrome (15), causing irritability, disruption of autonomic sleep patterns, heart rhythm and consciousness (15–17). Training and experience have strong influence on physiological and psychological responses. Experience is a critical factor in the development of optimal performance, whether in medicine (18), sports (19), or other extreme activities such as parachute jumps, in which experience modulates the psychophysiological response (26,37–39) (23). Resilience is inversely related to the perception of stress and can influence health-related behaviour, which in turn can help as a protective factor against psychological burden. Individuals who were previously physically active are more likely to respond to stress by increasing physical activity as a coping mechanism (behavioural activation). Therefore, resilience may serve as a key protective factor in times of adversity as a way to endure stressful moments (24).

This study is focused on the specifics of the military environment in terms of the influence of psychological burden associated with a soldier's assigned job to predict cardiometabolic risk in a group of "performance" units soldiers with the aim of proposing changes to the department's preventive programs.

Methods

This study retrospectively analysed the data obtained during extended annual preventive examinations (RRLP) of professional soldiers in the years 2012-2016 conducted at the Health Service Centers. The records are anonymous, contain any personal information and were released by Communications and Information Systems Division of the Military Health Agency upon request.

Probands aged 30–49 were selected from the RRLP cohort in 2012–2016. Data were checked and erroneous or partly missing data were discarded. Subsequently, the sample was divided into two cohorts. The first "performance" cohort included soldiers from combat units and paratroopers (aiborne). The second cohort consisted of "others", i.e. soldiers from non-combat units or airborne. The psychological burden was determined by the soldiers' assignment to a combat or airborne units. Both cohorts were divided by gender into two sets of men and women. Since age itself is a significant risk factor for MetS, the selection of probands was completed at 49 years of age and in each year of follow-up was divided by age into four subgroups namely 30-34, 35-39, 40-44, 45-49 years. Due to the significant disparity in the number of observed between the cohorts, the number of probands in the "others" age groups was adjusted so that it proportionally corresponded to the "performance" age groups.

Clinical assessment

Standardized procedures are established for measuring physical and anthropometric values. From the anthropometric indicators, body weight in kilograms is measured (in underwear, preferably in the morning, fasting, standard step-on scales), body height (altimeter, without shoes, preferably in the morning, the measured person stands on a surface perpendicular to the vertical axis of the altimeter, heels and toes are next to each other) (25). Waist circumference is measured at the narrowest point above the crests of the iliac bones, or at half the distance between the crests of the iliac bones and the lower edge of the ribs. Blood pressure is measured in the examination room sitting up, after 5-10 minutes of rest, at the forearm loosely supported at the level of the heart, with the back supported. Tonometers calibrated annually by the certification authority are used to measure blood pressure, semi-automatic devices with an appropriately wide and long cuff (with an arm circumference of up to 33 cm, the usual cuff is 12 cm wide, for an arm with a circumference of 33–41 cm, cuff width 15 cm and for arms over 41 cm, cuff width 18 cm) (25). Venous blood sampling is carried out in laboratories accredifed according to the ČSN EN ISO 15189 standard.

The categories of observed parameters are defined in Table 1.

In the personal questionnaire, the unit is listed, including the soldier's duty assignment and occupational character, rank, education level, smoking status, physical activity characteristics, family history, and psychological questionnaire.

The psychological burden is determined by the service classification of professional soldiers. Military personnel of combat units and paratroopers often perform a variety of physically and mentally demanding tasks in unique conditions of intense stress. For soldiers in the mentioned positions, the well-known specific stressors in the form of combat stress are assumed, i.e., a special requirement to perform actions that can end life of another person, or even the risk of losing one's own life (26). In current literature, the psychophysiological reactions of soldiers exposed to various stressors are described, but the influence of psychological burden of soldiers on the parameters of the MetS is not addressed in more detail in foreign publications.

Table 1. Specification of the evaluated parameters.

	Normal	**Risk I**	**Risk II**		
Waist circumference	≤94 cm	<102 cm	≥102 cm		
	Normal	**Incerased**			
Triglycerides	<1.7 mmol/l	≥1.7 mmol/l			
	Normal	**Risk**			
High-density lipoprotein	≥1.0 mmol/l	<1.0 mmol/l			
	Normal	**Incerased**			
Systolic blood pressure	<130 mmHg	≥130 mmHg			
Diastolic blood pressure	<85 mmHg	≥85 mmHg			
Glycaemia	≤5.6 mmol/l	>5.6 mmol/l			
	No	**Yes**			
Metabolic syndrome	<3 risk factors	≥ 3 risk factors			
	Normal	**Overweight**	**Obesity I**	**Obesity II**	**Obesity III**
Body mass index (weight in kilograms divided by height in meters squared)	<25 kg/m^2	<30 kg/m^2	<35 kg/m^2	<40 kg/m^2	≥40 kg/m^2
	Normal	**Incerased**			
Cholesterol	<5 mmol/l	≥5 mmol/l			
Low-density lipoprotein	<3 mmol/l	≥3 mmol/l			
Gamaglutamyltransferase	≤0.84 µkat/l	>0.84 µkat/l			
Alanine aminostrasferase	≤0.78 µkat/l	>0.78 µkat/l			
	Low	**Normal**	**Increased**		
Uric acid	<120 µmol/l	≤420 µmol/l	>340 µmol/l		
MS cis	number of parameters meeting MetS criteria				

Statistical data analysis

Statistical calculations were processed using Microsoft® Excel® for Microsoft 365, and NCSS 2021 Statistical Software (2021) was used to compare values. NCSS, LLC. Kaysville, Utah, USA, ncss.com/software/ncss.

Quantitative parameters are expressed as median, 1st and 3rd quartile, mean and standard deviation. To compare the performance units with the others in total and within individual age groups, the hypothesis of agreement against the alternative of disagreement was tested. Non-parametric Mann-Whitney (MW) or Kolmogorov-Smirnov (KS) tests were used, two-sample t-test if normality was not rejected. To compare age groups with each other within the "performance" units and the "others", the hypothesis of agreement was tested against the alternative that at least two groups differ significantly from each other. Non-parametric Kruskal-Wallis analysis of variance (KW) was used followed by Dunn's multiple comparison test with Bonferroni modification of significance level.

Qualitative parameters are classified according to their values into individual categories and presented as percentages of frequency. To test the hypothesis of independence against the alternative of dependence, the chi-square test of independence or Fisher's exact test was used. The chosen significance level was $\alpha < 0.05$.

The basic research question is whether the psychological burden of the soldiers in "performance" units increases the risk of MetS, even though their physical fitness is higher than that of the "other" soldiers. A chronic effect of the psychological burden of combat stress associated with the service assignement can be expected and this can affect the observed values. In such a case, the MetS could occur more frequently.

Results

From 2012-2016, a total of 49,666 RRLPs were carried out. During the gradual control and subsequent elimination and filtering of the necessary data, a total of 30,265 RRLP remained for further processing, of which 7,276 (6,961 men, 315 women) were in the "performance" group and 22,989 (19,984 men, 3,005 women) in the "others" group. Criteria for exclusion were incomplete or erroneous data. Further reduction in the number of data was due to maintaining the proportion of probands within the compared groups as there were significantly more of the "others". For the purposes of this article, the results of men in the years 2012-2016 are presented. The average age in the files is 39 years.

In the years 2012–2016, almost all of the compared parameters and the resulting statistically significant differences in relation to the MetS are better (HDL higher) in the "performance" group. The exception is the higher incidence of overweight in the "performance" group in individual years, the dependence is caused by the greater presence of obesity in the "others" group, table 2. BMI is calculated as the ratio of weight in kg to the square of height in metres (BMI = weight [kg]/height^2 [m^2]). Normal BMI ranges from 18.5-25 kg/m^2. Values below 18.5 kg/m^2 indicate underweight, values above 25 kg/m^2 indicate overweight, and values above 30 kg/m^2 indicate obesity.

Table 2. Distribution of overweight and obesity I according to BMI in percentage frequency in male cohorts.

Year	"Others" Overweight	"Performance" Overweight	"Others" Obesity I	"Performance" Obesity I	p-value
2012	58.1	61	15.8	9.6	**<1.00E-04**
2013	58.4	61	14.4	10.3	**5.00E-04**
2014	57.6	63.4	14.4	9.6	**<1.00E-04**
2015	57	63	15.2	9.5	**<1.00E-04**
2016	57.8	63.1	15	9.5	**<1.00E-04**

Overweight <30 kg/m^2; obezity I 30-35 kg/m^2; $\alpha < 0.05$

In the quantitative parameters, there are higher median and mean in the "performance" in 2014, 2015 and 2016 for glycaemia and ALT, summarized in table 3.

Table 3. Glyceamia and ALT values as median and mean in each year, comparing "performance" with "others".

	Median	Mean (SD)	Median	Mean (SD)	
2012	"others" (n=5533)		"performance" (n=1202)		p-value
Glycaemia	4.85	4,86 (0.68)	4.8	4.81 (0.64)	8.77E-02
ALT	**0.55**	**0.64 (0.39)**	**0.51**	**0.6 (0.87)**	**<0.0001**
2013	"others" (n=3683)		"performance" (n=1356)		
Glycaemia	**4.8**	**4.81 (0.64)**	**4.87**	**4.9 (0.64)**	2.00E-05
ALT	0.54	0.63 (0.43)	0.53	0.6 (0.32)	2.37E-01
2014	"others" (n=3371)		"performance" (n=1429)		
Glycaemia	4.8	4.85 (0.76)	4.86	4.87 (0.57)	3.89E-01
ALT	0.52	0.61 (0.37)	0.54	0.62 (0.37)	8.41E-02
2015	"others" (n=3742)		"performance" (n=1457)		
Glycaemia	4.86	4.87 (0.67)	4.9	4.89 (0.58)	8.37E-02
ALT	0.54	0.62 (0.38)	0.55	0.62 (0.31)	3.00E-01
2016	"others" (n=3655)		"performance" (n=1517)		
Glycaemia	**4.84**	**4.87 (0.67)**	**4.89**	**4.9 (0.71)**	**4.37E-02**
ALT	0.55	0.63 (0.37)	0.56	0.63 (0.3)	1.47E-01

SD – standard deviation; glycaemia in mmol/l; ALT = alanine aminotransferse in µkat/l; $\alpha < 0.05$

Qualitative parameters are presented in table 4 and 5, statistically significant results are highlighted.

Table 4. Risk factors of MetS as percentage of frequency in years 2012-2016, comparing "performance" with "others"

	"others"			"performance"			
WC	normal	risk I	risk II	normal	risk I	risk II	p-value
2012	**56.5**	**27.4**	**16.1**	***70.9***	**21.4**	***7.7***	**<0.0001**
2013	**61**	**25.7**	**13.3**	***71.9***	**20.8**	***7.3***	**<0.0001**
2014	**61.6**	**25.2**	**13.2**	**71.6**	**21.2**	**7.2**	**<0.0001**
2015	**61.4**	**25.6**	**13**	***67.6***	**22.5**	***9.9***	**1.00E-04**
2016	**60.7**	**25.3**	**14**	***69.8***	**21.8**	***8.4***	**<0.0001**
TG	normal	increased		normal	increased		
2012	**66.8**	**33.2**		**73.5**	***26.5***		**<0.0001**
2013	**68.9**	**31.1**		**75.3**	***24.7***		**<0.0001**
2014	**68.8**	**31.2**		**75**	**25**		**<0.0001**
2015	**68.5**	**31.5**		**75**	***25***		**<0.0001**
2016	**70.7**	**29.3**		**75.4**	***24.6***		**9.00E-04**
HDL	normal	risk		normal	risk		
2012	**82.2**	**17.8**		**85.4**	***14.6***		**8.70E-03**
2013	**83.3**	**16.7**		**87**	***13***		**1.30E-03**
2014	86.6	13.4		87.7	12.3		3.39E-01
2015	**86.1**	**13.9**		**88.7**	***11.3***		**1.61E-02**
2016	**85.9**	**14.1**		**89.6**	***10.4***		**5.00E-04**
SBP+DBP	normal	increased		normal	increased		
2012	**54**	**46**		**63.2**	***36.8***		**<0.0001**
2013	**58.1**	**41.9**		**63.6**	***36.4***		**4.00E-04**
2014	**61.7**	**38.3**		**67.3**	***32.7***		**2.00E-04**
2015	**61**	**39**		**74.9**	***25.1***		**<0.0001**
2016	**60.7**	**39.3**		**70.6**	***29.4***		**<0.0001**
Glycaemia	normal	increased		normal	increased		
2012	**88.7**	**11.3**		**90.8**	***9.2***		**3.45E-02**
2013	90.1	9.9		90.3	9.7		8.56E-01
2014	90.3	9.7		91.7	8.3		1.47E-01
2015	88.5	11.5		90.8	9.2		1.86E-01
2016	90	10		91.3	8.7		1.52E-01
MetS	no	yes		no	yes		
2012	**78.4**	**21.6**		**88.1**	***11.9***		**<0.0001**
2013	**81.7**	**18.3**		**87.1**	***12.9***		**<0.0001**
2014	**82.9**	**17.1**		**87.7**	***12.3***		**<0.0001**
2015	**82.1**	**17.9**		**88.7**	***11.3***		**<0.0001**
2016	**81.9**	**18.1**		**89.8**	***10.2***		**<0.0001**

WC = waist circumference normal ≤94 cm, risk I <102 cm, risk II ≥102 cm; TG = triglycerides normal <1.7 mmol/l, increased ≥1.7 mmol/l; HDL = high density lipoprotein risk <1.0 mmol/l, normal ≥1.0 mmol/l; MetS = metabolic syndrome, yes ≥ 3 risk factors.

Since the same probands could be repeated in the cohorts during follow-up by comparing the cohorts divided according to the RRLP carried out in the individual years 2012, 2013, 2014, 2015, or 2016, the development over time can only be compared between the years 2012 and 2016 and that in age subgroups formed after four years 30–33, 34–37, 38–41, 42–45, 46–49, when these subgroups are always made up of different probands. In the age subgroups of the "others", statistically significant better values in relation to MetS prevail in 2016 compared to 2012. Worse parameters are observed in a lower incidence of normal levels of total cholesterol and LDL, chart 1. When comparing the years 2012 and 2016, the age subgroups of the "performance", statistically significant better values in relation to the MetS in 2016 prevail in the MetS parameters. However, worse parametrs have been also observed. There is a statistically significant difference in BMI, ALT and uric acid.

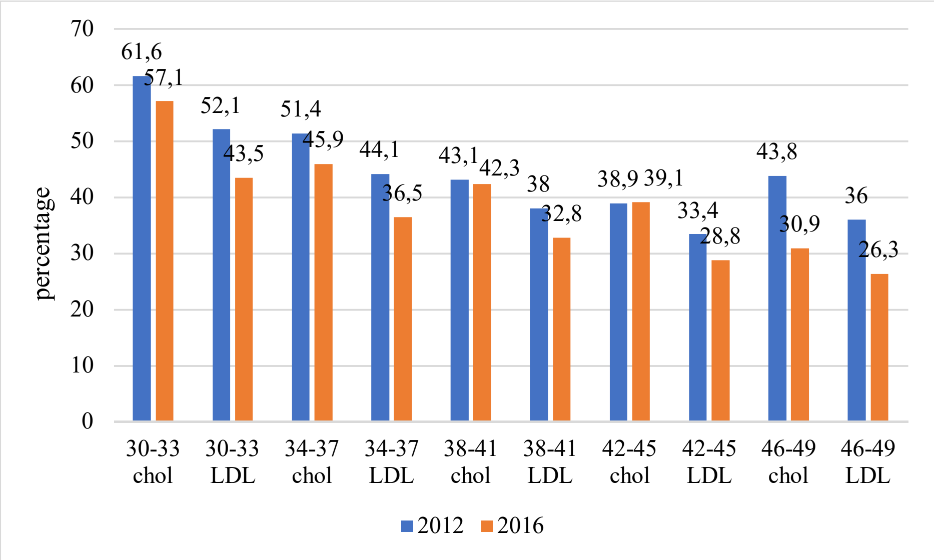
Table 5. Risk factors related to MetS as percentage of frequency in years 2012-2016, comparing "performance" with "others".

		"others"			"performance"		
BMI	normal	OW	obesity	normal	OW	obesity	p-value
2012	**24.1**	**58.1**	**17.8**	**28.3**	**61**	***10.7***	**<0.0001**
2013	**25.8**	**58.4**	**15.8**	**28**	**61**	***11***	**5.00E-04**
2014	**26.5**	**57.6**	**15.9**	**26.2**	**63.4**	***10.4***	**<0.0001**
2015	**26.1**	**57**	**16.9**	**26.7**	**63**	***10.3***	**<0.0001**
2016	**25.5**	**57.8**	**16.7**	**26.4**	**63.1**	***10.5***	**<0.0001**
Cholesterol	normal	increased		normal	increased		
2012	48	52		50.4	49.6		1.32E-01
2013	**46.4**	**53.6**		***52.5***	**47.5**		**1.00E-04**
2014	49.9	50.1		51.7	48.3		2.53E-01
2015	49	51		51.5	48.5		1.11E-01
2016	**45**	**55**		***49.1***	**50.9**		**9.80E-03**
LDL	normal	increased		normal	increased		
2012	41.1	58.9		41.1	58.9		9.94E-01
2013	41.7	58.3		43.9	56.1		1.75E-01
2014	37.3	62.7		38.9	61.1		3.07E-01
2015	39.3	60.7		38.8	61.2		7.14E-01
2016	**34.7**	**65.3**		***38.9***	**61.1**		**5.30E-03**
GMT	normal	increased		normal	increased		
2012	**79.1**	**20.8**		**87.2**	***12.8***		**<0.0001**
2013	**82.3**	**17.7**		**87.1**	***12.9***		**1.00E-04**
2014	**81.8**	**18.2**		**87.8**	***12.2***		**<0.0001**
2015	**81**	**19**		**85.2**	***14.8***		**4.00E-04**
2016	**81.7**	**18.3**		**88**	***12***		**<0.0001**
ALT	normal	increased		normal	increased		
2012	**76.8**	**23.2**		**82.2**	***17.8***		**1.00E-04**
2013	**78.3**	**21.7**		**80.9**	***19.1***		**4.88E-02**
2014	79.7	20.3		79.8	20.2		9.51E-01
2015	78.3	21.7		80.3	19.7		1.13E-01
2016	79.2	20.8		79.3	20.7		9.55E-01
UC	normal	low	incresed	normal	low	incresed	
2012	**83.7**	**2.4**	**13.9**	**80.6**	***5.9***	**13.5**	**4.10E-05**
2013	84.4	0.2	15.4	86.4	0.2	13.4	2.08E-01
2014	82.6	0.2	17.2	83.6	0.3	16.1	6.11E-01
2015	82.8	0.2	17	85.3	0.1	14.6	8.43E-02
2016	83.5	0.1	16.4	85.6	0.1	14.3	2.06E-01

BMI normal <25 kg/m², OW = overweight <30 kg/m², obezity ≥30 kg/m²; cholesterol normal <5 mmol/l, increased ≥5 mmol/l; LDL = low density lipoprotein normal <3 mmol/l, increased ≥3 mmol/l; GMT = gamaglutaryltransferase normal ≤0.84 µkat/l, increased >0.84 µkat/l; ALT = alanine aminotransferase normal ≤0.78 µkat/l, increased >0.78 µkat/l;
UC = uric acid low <120 µmol/l, normal ≤420 µmol/l, increased >420 µmol/l

The development over time of the values of cholesterol and LDL for the "others", ALT and uric acid for the "performance" in the age categories compared in 2012 and 2016 is shown in figures 1-2. The development over time of BMI and WC for "performace" is shown in table 6.

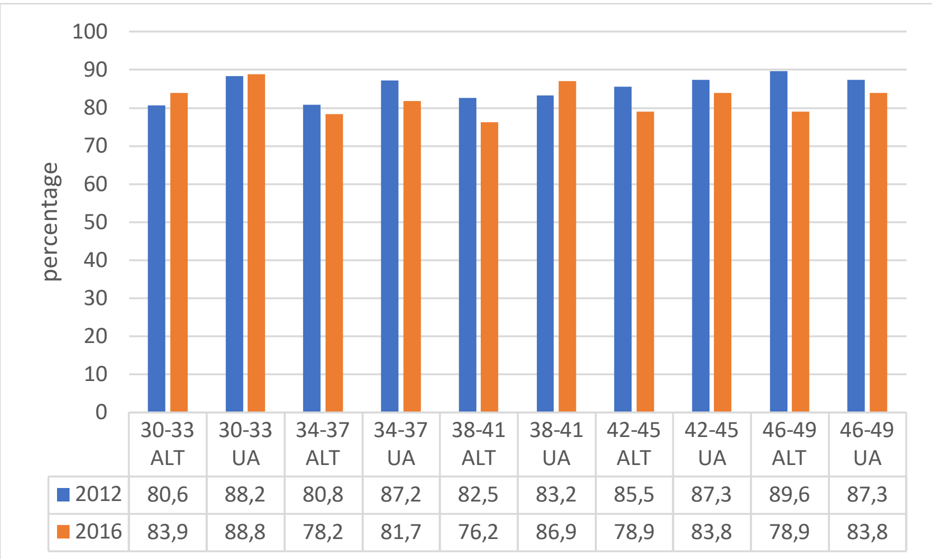
Figure 1. Bar charts of trends in normal cholesterol and LDL-cholesterol levels for "others" in age subgroups comparing 2012 and 2016.



chol = cholesterol normal <5 mmol/l; LDL = low density lipoprotein normal <3 mmol/l; α <0.05.

age	30-33	34-37	38-41	42-45	46-49	
chol	**3.08E-02**	6.03E-02	6.73E-01	9.18E-01	**4.00E-04**	p-value
LDL	**1.00E-04**	**1.04E-02**	**1.06E-02**	**2.98E-02**	**6.30E-03**	p-value

Figure 2. Trends of percentage frequency of normal ALT and uric acid levels for "performance" in age subgroups compared between the years 2012 and 2016.



ALT = alanine aminotransferase normal ≤0.78 µkat/l; UA = uric acid normal ≤420 µmol/l; α <0.05.

age	30-33	34-37	38-41	42-45	46-49	
ALT	2.04E-01	5.30E-01	**4.67E-02**	7.77E-02	6.86E-02	p-value
UA	**<0.0001**	**3.39E-03**	**3.60E-05**	4.59E-01	6.32E-01	p-value

Table 6. The development over time of BMI and WC for "performace" in age subgroups in percentage of frequency compared the years 2012 and 2016.

	"performance" 2012			"performance" 2016			
WC	normal	risk I	risk II	normal	risk I	risk II	p-value
30-33	79.80	14.90	5.30	84.60	12.10	3.30	1.42E-01
34-37	68.60	25.60	5.80	76.50	17.70	5.80	8.80E-01
38-41	62.20	27.10	10.70	63.70	26.70	9.60	8.75E-01
42-45	62.20	29.60	8.20	61.80	26.80	11.40	4.96E-01
46-49	50.00	31.80	18.20	52.70	30.00	17.30	9.40E-01
	"performance" 2012			"performance" 2016			
BMI	normal	OW	obesity	normal	OW	obesity	p-value
30-33	**58.70**	**33.80**	**7.90**	**40.00**	**55.70**	***4.30***	**4.39E-02**
34-37	29.20	61.60	9.20	28.70	63.20	8.10	4.82E-01
38-41	23.90	63.20	12.90	20.10	66.40	13.50	5.33E-01
42-45	20.80	64.20	15.00	22.40	64.90	12.70	8.57E-01
46-49	22.40	59.70	17.90	10.80	71.20	18.00	1.71E-01

WC = waist circumference normal ≤94 cm, risk I <102 cm, risk II ≥102 cm;
BMI normal <25 kg/m^2, OW = overweight <30 kg/m^2, obezity ≥30 kg/m^2; α <0.05.

Discussion

Various psychophysiological reactions of soldiers exposed to specific stressors are described in the current literature. but the influence of the psychological burden of soldiers in a comparison of "performance" and "other" units on the parameters of the MetS is not addressed in more detail in foreign publications.

The results of our study point to a better state of cardiometabolic markers in the cohort of soldiers assigned to combat positions ("performance"). These soldiers are also called tactical athletes with high demands on physical and mental fitness (27).

Metabolic syndrome

A 2019 meta-analysis of the prevalence of MetS among armed forces personnel of various nations can be found, where, according to NCEP-ATP III criteria, the overall MetS prevalence estimate among the involved soldiers was 8.0% and 9.6% based on the IDF definition. Of which Korean soldiers 0.8% (2018), Iranian soldiers 11% (2017), 8.1% (2010), Iranian paratroopers 5.2% (2012), US Army soldiers 11.3% (2016), French soldiers 9% (2008), 9% (2005) and Saudi Arabian soldiers 18.6% (2005) according to NCEP-ATP III criteria. According to the IDF criteria for the Brazilian Navy 17.9% (2011) and the soldiers of the Finnish Army 7% (2012) (28). As mentioned above, due to the possibility of representation of the same probands in individual years, it is not possible in our study to simply add up the annual results and draw conclusions. Therefore, the prevalence of MetS by individual years is shown: in 2012 16.75% ("other" 21.6%, "performance" 11.9%), 2013 15.6% (18.3% resp. 12.9%), 2014 14.7% (17.1% resp. 12.3%), 2015 14.6% (17.9% resp. 11.3%) and in 2016 14.15% (18.1% resp. 10.2%). For the classification, the so-called "harmonized" definition of MetS based on NCEP ATP III was used, see above, the criteria of which are stricter than the standard definition. Specifically, in the waist circumference, where NCEP ATP III states the maximum limit of the standard for men to be 102 cm compared to 94 cm in the Czech Republic. This may be the reason for the higher occurrence of MetS in the Czech Armed Forces compared to other armies. For example, the first study of Iranian paratroopers shows differences in the results of the presence of MetS according to NCEP ATP III of 5.2% and according to IDF of 13.5% in the same sample (29).

Body mass index and waist circumference

In our findings, in the individual years 2012-2016, a higher incidence of overweight in the "performance" group (combat units + paratroopers) is repeated. Analysis of the Iranian military showed (accoring to BMI) that the lowest prevalence of overweight was in the land forces (12%) and the highest in the naval forces (64%). For obesity, the lowest prevalence was in the Air Force (11%) and the highest in the Army and Navy (15%). In both cases were slightly higher after 2014 (8). The results of a study of military professionals of the Czech Armed Forces point out that in the years 1999-2009, only a third of military professionals of the Czech Armed Forces had a normal body weight. During the study period, there was an increase in the number of individuals with BMI values in the overweight range from 52% to 57.1%, with the assumption of overestimation due to the inclusion of individuals with increased body weight due to well-developed musculature (30).

The prevalence of overweight in the male cohort in this study is lowest in 2012 at 59.5% and highest in 2015 at 62%. The prevalence of obesity is lowest in 2014 at 13.15% and highest in 2012 at 14.25%. A total of 25.95% of soldiers had a normal BMI in 2016. Compared to 2009, this shows a decrease in normal weight in males (28.4%) (30). Table 7 shows the prevalence of obesity and mean BMI values for males in the Czech population in 2015-2018 (31) compared to the population of military professionals in 2009 and 2016. Comparing to the Czech population, military professionals are significantly less obese, and the differences in mean BMI values are not as pronounced. This is due to the high prevalence of overweight among military professionals.

Table 7. Obesity and BMI in the civilian population of the Czech Republic in 2015-2018 and in the military population of the Czech Republic in 2009 and 2016.

	Civilian men 2015-2018	Soldiers men 2009	Soldiers men 2016
BMI (kg/m^2)	29.1 ± 4,8	26.9 ± 3.2	27 ± 3
Obesity by BMI	37.3 %	14.5 %	13.6 %

BMI reported as mean and standard deviation; obesity reported as a percentage frequency.

BMI is still the most widely used measure of overweight and obesity at the population level. However, it cannot distinguish between muscle mass, the amount and distribution of body fat, and therefore it is an indirect measure of obesity (32). Therefore, to eliminate overestimation of obesity by BMI alone, waist circumference is also measured in the RRLP. Table 8 presents a comparison of waist circumference in 2009 and 2016 for the Czech soldiers. For men, there was an improvement in all parameters. This development is consistent with the trend between 1999 and 2009 (30).

Table 8. Waist circumference of the military male population in 2009 and 2016.

WC	2009	2016
Normal	60.1 %	64.3 %
Risk I	25.7 %	23.5 %
Risk II	14.3 %	11.2 %

WC = waist circumference normal ≤94 cm, risk I <102 cm, risk II ≥102 cm; reported as a percentage frequency

Current knowledge predicts that occupation-related factors have a high influence on the prevalence of overweight and obesity. A possible explanation for overweight and obesity among soldiers (increase in 2016 at age 30-33 in our study) is exposure to a higher risk of stressful conditions, exposure to death or harmful agents, and permanent sleep deprivation, especially in the position of performance units (33–36) That includes bad eating habits, intake of higher amounts of energy, saturated fat and saccharides (37, 38). A stressful environment can lead to increased appetite through cortisol reactivity (39,40). Sleep disturbances are also known to be associated with body weight and increased fat storage (41, 42).

Hyperglycaemia

A statistically significant difference in higher glucose values in "performance" units was found only once, in 2016. The other differences were not statistically significant. The highest prevalence of hyperglycemia in "performance" was 9.7% in 2013 and the lowest in 2014 at 8.3%. Hyperglycaemia may be due to an error in the diet prior to sampling or glucose metabolism disorders. However, there is also the possibility of an association with stress, which initiates reactions leading to activation of the hypothalamic-pituitary-adrenal (HPA) axis and stimulation of the sympathetic nervous system with increased levels of cortisol and pro-inflammatory cytokines (43), which can induce non-alcoholic fatty liver disease (NAFLD) (44) and insulin resistance (45), leading to hyperglycaemia. In addition, epinephrine stimulates glycogenolysis in the liver, resulting in higher serum glucose levels that provide energy for the defense response. This may be one of the reasons why the "performance" group in our study has shown a higher level of glycaemia.

Alanine aminotransferase

Another parameter that can be observed several times to be statistically significantly higher in "performance" cohort is alanine aminotrasferase (ALT), figure 2, table 5.

The degree of activation of the HPA axis in patients with NAFLD is closely related to the level of pathological changes in liver (46). However, there is still insufficient evidence to explain the mechanism responsible for stress-associated liver damage. Clinical cases with elevated liver enzymes without known causes are often observed. Clearly, a possible cause could be a stress response (47). HPA can lead to low-grade inflammation that causes fat to build up in liver cells, and persistent liver inflammation results in liver damage. Depression, anxiety, and other negative emotions are a psychological reaction to stress, so they play a role in the inflammatory response of the liver (48). In a 2020 Korean population-based study of apparently healthy men and women, a significant association of worse perceived stress with a higher prevalence of NAFLD was demonstrated for the first time, independent of risk factors (smoking, alcohol consumption, lack of physical activity) (49). Stress may be one reason why the "performance" group in our study had higher ALT values.

On the other hand, liver enzymes can also be elevated due to extrahepatic causes, typically during muscle injury, when transaminases can be increased during acute myocardial infarction, hemolysis, trauma, or after extreme physical exertion. Muscles have a larger volume of tissue, than the liver, so they contain more aspartataminotrasferase (AST) and ALT compared to the liver (50). In a study (50) involving healthy men who regularly engaged in moderate physical activity that did not involve prior weightlifting, ALT, AST, lactate dehydrogenase (LDH), creatine kinase (CK), and myoglobin levels increased significantly after 1 hour of heavy weightlifting and remained elevated for at least 1 week. Bilirubin, GMT, and ALP levels remained within the reference range. If the CK level were not determined in this case, there could be erroneous conclusions that elevated transaminase levels are a manifestation of liver damage, which could lead to further investigations including an invasive procedure such as a liver biopsy. If elevated transaminase values appear, the medical history should also include a question about exercise habits (mode of exercise) and the inclusion of CK and LDH blood sampling in the screening panel (51). Another indicative parameter to quickly exclude liver damage is the AST/ALT ratio. A Swedish study demonstrates that the AST/ALT ratio was > 1 in almost all subjects within 7 days after exercise. However, at follow-up (10-12 days after exercise) most subjects had an AST/ALT ratio < 1 and an ALT concentration above the upper reference limit range. This may be explained by the longer half-life of ALT (47 h) compared to AST (17 h) (52). If liver function tests are performed at this point, it can give a misleading picture that suggests mild liver disease. In accordance with these results, it is advisable to introduce a restriction of intensive muscle training for at least 1 week before blood sampling.

Dyslipidaemia

In "others" units, statistically significantly higher LDL levels were observed in 2016 compared to 2012, figure 1, table 4, table 5. The average total cholesterol (chol) levels in Czech men in 2015-2018 were 5.26 mmol/l (31). The average chol values in 2016 were 5.1 mmol/l for male soldiers. In 2009, the values were identical (30). The lower chol values in professional solders reflect the lower prevalence of obesity in this population.

Elevated serum lipid levels may be due to simple dietary errors. The influence of chronic stress leading to elevated cortisol levels and to a predilection for high-fat, high-glycemic index foods and excessive alcohol use may also be considered.

A Chinese study confirmed in rat experiments that acute stress impairs normal liver function, affects lipid efflux from hepatocytes and subsequently lipid metabolism, leading to increased serum immunoglobulin and LDL levels, decreased serum albumin and HDL levels, and inhibition of reverse cholesterol transport gene expression. Since the acute stress was not long and severe enough in this study, there was no severe liver damage with subsequent elevation of ALT and AST (53). Similarly. the results of a Spanish study support the hypothesis of a link between between occupational stress and lipid metabolism disorders (54).

The results of the "others" group from 2016 would indicate a worse cholesterol metabolism independent of other parameters of the MetS. In addition to the above theory, an explanation is offered in secondary hyperlipoproteinemia and an incorrect eating habits.

Hyperuricaemia

Statistically significant differences in uric acid (UA) levels between the study groups were rare. However, when compared over time for both "performers" and "others", statistically significant higher levels are evident in 2016 compared to 2012, figure 2.

The main source of purines in the body is their increased intake through food and sweetened beverages. Alcohol contributes to hyperuricemia by increased production and decreased excretion of urate (55).

In terms of psychological distress, individuals with elevated uric acid levels may be more likely to be impulsive, hyperactive, and disinhibited. While low levels of uric acid are associated with socially anxious, introverted, and avoidant tendencies (56). Uric acid is a naturally occurring endogenous substance, in psychology associated especially with psychopathology related to emotions (e.g. anxiety and depression). Functional magnetic resonance imaging was used to examine the activity of the bilateral hippocampal complex during a psychosocial stress task, which varied with uric acid concentration. Specifically, activity in the hippocampus and surrounding cortex increased in association with uric acid levels. The findings suggest that uric acid levels modulate stress-related hippocampal activity. Given that the hippocampus is involved in emotion regulation during psychosocial stress, these findings offer a potential mechanism by which uric acid affects mental health (56). In another study, serum uric acid was identified as a biochemical marker of temperament in both men and women. The therapeutic effect of uric acid lowering treatment in externalizing psychiatric disorders suggests that hyperuricemia contributes to these disorders in some cases. These results provide a pathophysiological basis for the use of allopurinol, a uric acid lowering drug, as a psychiatric treatment for externalizing disorders (57).

The above-mentioned studies indicate the possibility of psychological stress influencing uricaemia, however, there remains the possibility of increased uric acid levels due to poor dietary habits in connection with the profession.

Futhermore, recent studies have confirmed the relationship between serum UA concentration and MetS parameters. Specifically, dyslipidaemia characteristic for MetS (low HDL-C and high TG) correlates more strongly with UA levels than with insulin resistance. Waist circumference also correlates better with UA levels than BMI. Thus, increasing serum KM levels could be associated with higher CV risk (58).

Clinical implications

This study confirmed the necessity of waist circumference measurement as an important parameter to eliminate overestimation of obesity in overweight persons without at-risk waist circumference. Further studies should pay more attention to appropriate methodology so that a valid and accurate prevalence of overweight and obesity in military personnel can be determined.

With elevated levels of transaminases, the medical history should include questions about exercise habits (type of exercise, restriction of strenuous exercise 1 week before sampling), and blood sampling should include examination of CK and LDH.

Food selection or availability may also play an important role in the development of overweight and obesity, particularly in combat units. It would be appropriate to provide healthier food options along with portion control in military dining facilities.

Selective prevention programs targeting overweight and obesity by military unit type including weight self-monitoring, nutrition education, physical activity at least three days per week and psychological support for individuals who eat when experiencing negative emotions would be appropriate (59).

In the context of building psychological resilience, it would be advisable for combatant commanders to ensure that initial and ongoing training is sufficiently challenging to ensure a high level of readiness. Ensure that soldiers are prepared for the stressors of deployment, including ongoing validation (60).

Limitations of study

The definiton of psychological stress is the limitation. A valid, standardized psychological questionnaire for assessing psychological distress in soldiers does not exist in the Czech language (61). One of the questionnaires used for research in the United States Army, the CD-RISC (Conor-Davidson Resilience Scale) (24), has been translated into Czech language, but no factor analysis has been conducted to verify the psychometric characteristics of the Czech version (62).

Thus, the definition of psychological stress is based on the assignment of the soldier at either combat or airborne units ("performance"). This characterisation of stress is based on the job categorisation. Soldiers assigned to these positions must undergo special medical, physical and psychological examinations.

Conclusion

It was found that soldiers assigned to units with a higher physical and psychological burden do not have a higher incidence of metabolic syndrome compared to "others".

Considering the mandatory regular physical training of every professional soldier and the claim that traditional risk factors do not fully explain the development of CVD, the worse results of MetS parameters in the group of "others" could be a consequence of chronic occupational stress (busy environment, excess of visual or auditory sensations, long-term stereotyped work).

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Conflict of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

Adherence to Ethical Standards

This article does not contain any studies involving animals performed by any of the authors. This article does not contain any studies involving human participants performed by any of the authors.

Personal data have not been handled in this study

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