Iran J Public Health, Vol. 49, No.12, Dec 2020, pp.2376-2383

Original Article

Body Mass Index and Measures of Body Fat for Defining Obesity and Underweight: A Cross-Sectional of Various Specialties in Montenegrin Army Soldiers

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(Received 14 Jun 2020; accepted 16 Aug 2020)

Abstract

Background: The body composition and physical fitness of members of the army is always a relevant topic for research, since the level of defense and security of people and material goods in a specific territory in many ways depends on the level of ability of the army. However, members of the armed forces are a heterogeneous group, typified by different abilities, characteristics, but also everyday needs, and the trend of changing body composition and reducing physical fitness is a current issue that has not bypassed this population either. Therefore, this study aimed to determine possible differences in body composition indicators that could appear between members of the Army of Montenegro of different military specialties.

Methods: The sample of respondents included 240 Montenegrin male soldiers (32.5yr±9.5), who were measured at the sports dispensaries within the barracks of Montenegrin Army around the country in the spring of 2020, was classified into eight numerically equal subsamples according to their military specialty. The sample of variables included five anthropometric measures, which were necessary to calculate two derived body composition indicators: Body Mass Index (BMI) and Body Fat Percentage (FAT %). Using the one-way ANOVA and Post Hoc test with Taki's model, the variables were analyzed.

Results: It was determined that the body composition of Montenegrin soldiers shows a certain peculiarity compared to other national military corps, while there are differences in body composition indicators between members of the Montenegrin Army of different military specialties.

Conclusion: This fact dramatically strengthens the issues of Montenegrin distinctive regarding body composition, both in general terms and in terms of distinctive within specific professional vocations.

Keywords: Anthropometry; Nutrition; Physical fitness; Military; Montenegro

Introduction

The body composition and physical fitness of members of the army is always a relevant topic for research, since the eventual level of defence and security of people and material goods in a specific territory in many ways depends on the level of ability of the army. Because the trend of changing body composition and reducing physical fitness in recent decades remains relevant in the general population (1), it is necessary to emphasize that this trend has not bypassed members of the armed forces (2). Evidence that suggests that members of the U.S. armed forces

encounter the aforementioned problem to a significant extent (3) , thus they are considered inadequately prepared to perform tasks in their armed formations, because they are unable to meet prescribed standards, primarily in strength and durability (2, 4). The trend of changing body composition and reducing physical fitness in members of the armed forces of other countries around the world is not unknown (5-9); a significant number of previous studies highlight the link between physical fitness and body composition, recommending that regular physical activity, healthy nutrition, and self-weight management for a wide range of health, professional and work benefits, including physical and cognitive abilities and resistance to various diseases (10-12).

There is a significant bond between obesity and poorly performed tests to assess physical fitness in British armed forces; they also assert that the body mass index (BMI) and specific parameters for assessing obesity represent very good indicators for determining the physical abilities of members of the armed forces, so those indicators have been widely used (13).

In contrast, inadequate body composition not only reduces the abilities of members of the armed forces but also significantly increases the probability of getting various diseases (3, 14). The appearance of disease, in addition to further deterioration of physical and cognitive abilities, significantly increases the financial allocations for health, as well as other costs, which are primarily reflected in the reduced productivity of employees.

Both of the issues mentioned in previous two paragraphs burden the planned annual budgets in the ministries of defence in countries throughout the world (15), so politicians are very interested in obtaining timely information related to factors affecting the health and physical abilities of members of the armed forces, and research in this area is becoming valuable.

In the previous two decades, a significant amount of research has been conducted examining the health status, physical fitness, and daily needs of soldiers from a global perspective; however, not much research has focused on subsamples of this very heterogeneous population and their specificities (16). A significant number of studies in their recommendations for future research merely state that this segment should be explored in the near future (17). Specifically, members of the armed forces of a country have an extensive range of activities in which they engage their human resources, so this population represents a very heterogeneous group observed from many perspectives. There are different needs in the Air Force, Navy and Army, or in Special Task Forces and the Military Police (18), and the need for additional research is evident, mainly because it is necessary to identify differences in the factors that protect or endanger the health and physical fitness of pilots and flying technician, air defence soldiers and air operations centre, special ground forces, naval saboteurs, logisticians, midfielders, military police and guards, in relation to the specifics of the call of each of these subgroups. These studies aimed to lead to the adjustment of programmes for these subpopulations, but also to bring political decisions that would improve the general health and physical ability of members of the armed forces in each country.

Given all the above, but also the fact that Montenegrin citizens have a specific body composition, and that overnutrition and obesity have not bypassed the citizens of Montenegro to some extent (19-21), and that few studies have dealt these issues (22, 23), it is crucial to examine the body composition of members of the Army of Montenegro, both in the total sample and by subsamples, in relation to various military specialties, all with the aim of determining the factors that may positively affect the level of health of members of the Army of Montenegro and, possibly maintaining their physical fitness and cognitive abilities, which are necessary for them to perform their everyday work tasks adequately.

Materials and Methods

As its subjects, this study included 240 active-

duty male soldiers from the Montenegrin Army that were 32.5±9.5 yr (age range 19–65yr). They were measured at the sports dispensaries within the barracks of Montenegrin Army around the country (Podgorica, Niksic, Pljevlja, Bar and Kolasin) in the spring of 2020. Three reasons qualified the selected individuals, that they were clinically healthy, which is confirmed by the existence of personal health records in which there are protocols of records of systematic medical examinations for the current year, also that they had no identified physical deformities, and that they were citizens of Montenegro at the time of measurement. The sample was divided into eight numerically identical subsamples, which included thirty pilots and flight technicians (36.3±7.2yr), then anti-aircraft defence and air-operations centre soldiers (39.4±7.0yr), special ground forces (25.6±7.4yr), naval saboteurs (30.3±6.5yr), logisticians (40.7±9.2yr), midfielders (34.1±10.4yr), military police officers (29.7±8.0yr) and guards (23.7±4.0yr).

The measurements of body composition included five anthropometric measures (body height, body weight, abdominal skin fold, chest skin fold, and thigh skinfold) that were carried out with the conventional technique according to the International Biological Program (25). These anthropometric measures were necessary to calculate two derived body composition indicators: body mass index (BMI) and body fat percentage (FAT %), as recommended by the Protocol of the Manual for Assessing Health-Related Physical Fitness (24). Body mass index was calculated using the following formulas: (BMI = Body Mass (kg) / Body Height (m^2)); while the Body fat percentage (FAT %) was calculated as follows (FAT % = 4.95 / body density - 4.50; body density = 1.10938 - 0.0008267 × (sum of three skin folds) + 0.0000016 × (sum of three skin folds) ^{2} - 0.00002574 x (years)). The trained measurers determined the selected anthropometric indicators (same measurer for each variable), while the quality of their performance was evaluated against the prescribed "IBP Manual" (25). Lastly, the age of each subject was attained directly from their birthdays.

The data were analysed with IBM SPSS 20 (Chicago, IL, USA) software. Estimations of the variables described in the previous paragraph were calculated descriptively for the whole sample, as well as for each sub-sample. One-Way Analysis of Variance (ANOVA) and Post Hoc test with Taki's model were performed to analyse indicators of the body composition of members of the Montenegrin Army, as well as differences in body mass index and body fat percentage between Montenegrin soldiers of different military specialities. Statistical significance was set at $P<0.05$.

After this research was reviewed and approved by the Senate of University of Montenegro No. 03-3020/5, the Montenegrin Army was informed about the project research in order to approve and support the data collection.

Results

The analysis of average values of anthropometric measures and derived indicators of body composition of members of the Army of Montenegro is shown in Table 1. Based on an overview of average age, it is noted that logisticians and members of air defence and air operations centre are the oldest, and the guards are the youngest soldiers. Midfielders and guards are characterized by the highest body height, while the lowest average values of this indicator were recorded in special ground forces. The highest values of body weight were present in midfielders and logisticians, and the lowest in special ground forces The highest average values of all skin folds were measured in members of the air defence and air operations centre, while guards, special ground forces and naval saboteurs have lower average values than the others. Body mass index and body fat percentage are highest among members of the air defence and air operations centre and logisticians, while their lowest values have guards and ground Special Forces.

Table 1: Anthropometric measures and body composition indicators of study sample and subsamples

Variables	*All*	*G*	*KS*	*L*	*PL*	*PD*	*PV*	*VP*	*V*
					Mean±SD				
Age(yr)	32.5±9.5	23.7±4.0	25.6±7.4	40.7±9.2	36.3±7.2	30.3±6.5	39.4±7.0	29.7±8.0	34.1±10.4
Body Height (cm)	181.7±6.2	184±4.9	179.6±5.5	180.6±6.3	180.2±4.4	181.4±6.3	182.9±7.6	181.1±6.4	184.2±6.8
Body Weight (kg)	90.1±13.1	87.2±8.7	83.2±13.4	93.1±13.1	88.5±8.8	86±8.7	98.9±16.5	90.4±12.9	93.4±14.7
Abdominal Skin Fold (mm)	22.7±12.0	15.3±7.5	15.3±9.2	29.8±9.7	25.2±9.2	16.4±6.9	31.2±11.1	22.3±11.2	26.1±16.3
Chest Skin Fold (mm)	5.2±1.9	4.7±0.9	4.4±1.3	5.6±1.9	5.1±1.5	4.2±0.9	6.6±2.6	5.1±1.9	5.9±2.3
Thigh Skin Fold (mm)	6.3±2.3	5.1±1.5	5.2±1.5	6.1±1.7	7.1±3.0	6.5±1.9	7.4±2.8	6.8±2.1	6.2±2.2
Body Mass Index (kg/m^2)	27.2±3.4	25.7±2.2	25.7±3.3	28.4±3.3	27.4±2.7	26.1±2.1	29.6±4.0	27.6±3.3	27.5±4.1
Body Fat Percentage (%)	10.5±4.9	6.5±2.2	6.8±3.4	13.9±3.1	12±3.2	7.6±3.0	14.6±3.7	10.4±4.7	11.7±6.5

Legend: G – guards; KS - special ground forces; L – logisticians; PL - pilots and flight technicians; PD - naval saboteurs; PV - anti-aircraft defence and air-operations centre soldiers; VP - military police; V – midfielders

Further inspection of the results in Table 2, confirmed on the basis of the obtained *F* values that represent the ratio of factor and residual variance, reveals that there are differences between the subsamples of respondents regarding BMI. Specifically, the mentioned *F* value is higher than the tabular *F* value, for which the level of significance is significantly lower than the theoretical 0.05.

Based on the results of Taki's Post Hoc test for BMI shown in Table 3, the groups that significantly deviate in the analysed variable compared to the others were determined.

Table 2: One-Way Analysis of Variance in BMI and FAT% of the study sample

Variables	*F*	*P*
BMI	5.38	.000
FAT%	19.15	.000

Legend: *F* – f test; *P* – probability level

These are guards in relation to logisticians and soldiers of the anti-air defence and air-operational centre; special ground forces in relation to logisticians and soldiers of the air defence and air-operational centre; naval saboteurs in relation to air defence and air operations centre soldiers.

Table 3: Post Hoc analysis of variance on BMI with study subsamples

Variable	*G*	*KS*	*L*	*PL*	*PD*	*PV*	*VP*
KS	1.000						
L	.027	.029					
PL	.489	.505	.908				
PD	1.000	1.000	.116	.825			
PV	.000	.000	.847	.130	.001		
VP	.318	.332	.974	1.000	.663	.236	
V	.374	.389	.957	1.000	.723	.194	1.000

Legend: G – guards; KS - special ground forces; L – logisticians; PL - pilots and flight technicians; PD - naval saboteurs; PV - anti-aircraft defence and air-operations centre soldiers; VP - military police; V – midfielders

In a review of the results were shown in Table 2, it was found that there are differences between the subsamples of the respondents regarding the FAT %. Specifically, the obtained *F* value is higher than the tabular *F* value, for which the level of significance is significantly

lower than the theoretical 0.05.

Based on the results of Taki's Post Hoc test for the body fat percentage (FAT %) are shown in Table 4, it was determined which groups differ significantly in the analysed variable compared to the others. These are guards in relation to logisticians, pilots and flight technicians, soldiers of air defence and air-operational centre, military police officers and midfielder; special ground forces in relation to logisticians, pilots and flight technicians, air defence and air operations centre soldiers, military police officers and midfielder naval saboteurs in relation to logistics, pilots and flight technicians, air defence and air operations centre soldiers and midfielders; military police officers in relation to logistics officers and soldiers of the air defence and air-operational centre.

Table 4: Post Hoc analysis of variance on FAT% with study subsamples

Variable	*G*	*KS*	*L*	*PL*	*PD*	*PV*	*VP*
KS	1.000						
L	.000	.000					
PL	.000	.000	.580				
PD	.962	.995	.000	.001			
PV	.000	.000	.998	.186	.000		
VP	.005	.014	.014	.745	.122	.001	
V	.000	.000	.333	1.000	.003	.074	.923

Legend: G – guards; KS - special ground forces; L – logisticians; PL - pilots and flight technicians; PD - naval saboteurs; PV - anti-aircraft defence and air-operations centre soldiers; VP - military police; V – midfielders

Discussion

This study provides an overview of existing indicators of body composition, both in general terms with regard to Montenegrin soldiers, and in particular with regard to military specialities. This study included 240 active soldiers, thirty of who belonged to each of the included military specialities: pilots and flight technicians, air defence soldiers and air operations centre, special ground forces, naval saboteurs, logisticians, midfielders, military police officers and guards. The original knowledge gained in this study can be used in the selection of new recruits in accordance with the characteristics that, above all this profession, but also each of the military specialities requires and can simultaneously enable direct comparisons of soldiers from different military specialities, which can be very important in situations in which military structures urgently need to be reclassified between different units with different military specialities.

Regarding the discussion on the results presented earlier, it is noteworthy that in the first place that the body height of professional members of the Army of Montenegro shows higher values compared to members of other armies. Montenegrin soldiers, as well as the Montenegrin general population, represent one of the tallest military populations (20, 21, 26). Only Serbian (180.2) and Finnish (180.0 cm) soldiers (11, 27) are approximately as tall as Montenegrins (181.7 cm), while Canadians are (178.0 cm), Belgians (177.5 cm), Americans (176.0 cm) and Turk (173.0 cm) are significantly shorter (7, 9, 12, 28). However, although the secular trend among Montenegrin soldiers is obvious, there is a hypothesis that the population in the Dinaric Alps, including the Montenegrin population, has not yet reached its full genetic potential, as in recent decades they have been under the impact of adverse environmental factors including wars and poor economic situations (29-31). Therefore, it is realistic to expect that the secular trend continues to affect the growth of the average height of men in Montenegro and, thus, Montenegrin soldiers. The current average height of Montenegrin soldiers (181.7 cm)

shows significantly higher values than those determined (32), in the 1980s in the Yugoslav National Army (1982=176.6 cm; 1989=178.9 cm.
In contrast, body weight increases with increasing body height, but this individual variable did not interest researchers much at the beginning of and during the 20th century, so data are lacking in comparison to those available for body height. However, the ratio of body weight and body height, as well as the body fat percentage captured the attention of researchers, mainly because they are the best indicators of the nutritional status of citizens and, consequently, the nutritional status of Montenegrin soldiers.
There are differences in BMI and FAT % among members of different military specialities. Specifically, guards, special ground forces, military police officers and naval saboteurs have significantly lower values in the mentioned variables compared to other subgroups of soldiers. The cause of this should, above all, be a more favourable age structure (23.7-30.3 yr), because more inferior nutritional status is conditioned by physiological and morphological changes associated with biological ageing (33). In contrast, the conditions for admission to the service of these soldiers are significantly more rigorous in terms of meeting the standards of body structures and the professional specialist training that follows them after general military training leads to the final selection, which produces the type of soldier who will meet the needs of the service. They are also subjected to dedicated training processes and specific training on a daily basis, so that their units are in a constant state of preparedness to react in a short time from the moment a crisis arises.
In contrast, pilots and flight technicians, logisticians, midfielders, anti-aircraft defence and air operations centre soldiers (34-40.7 yr), have significantly higher values of treated variables. Specifically, in these military specialities, soldiers are primarily working with the use of highly sophisticated military equipment. Therefore, their physical activity and the ability to set aside more time for physical activity is reduced to a minimum time. However, although there are differences, so we can divide Montenegrin soldiers into those who are better or worse, it is worth emphasizing that, in accordance with the Cooper Institute's Fat Assessment Standards (25), Montenegrin soldiers show good results and the situation is not of concern.
This study is not without limitations. As injury prevention and rehabilitation are issues that may be important when raising the ability of those engaged in physical activities (34), as is the case with a significant number of analysed respondents (i.e., members of certain military specialities), it is necessary to point out that the possible influence of this factor was not taken into account. This factor may have had a disruptive effect on the analysed variables, especially because body composition indicators could show significantly lower values after injury and rehabilitation periods. However, although there were such cases, it was not represented on a large scale.
In contrast, the main strength of this study is the quality and large sample, which resulted by creating model characteristics of the Montenegrin soldier with regard to body composition indicators, but also the characteristics of each military speciality within the specified population. The recommendation for future research, given the heterogeneity of the military composition of the Army of Montenegro, is based on the idea of including the entire composition of the Montenegrin military population, systematic measurements, organized over a specified period, which would be on the official agenda of the Montenegrin army and multi-annual strategy.

Conclusion

The most important thing is to emphasize that policymakers at the Ministry of Defence in the Government of Montenegro and leaders in military structures in the field should consider using the results of this research as a basis for primarily monitoring the nutritional status of Montenegrin soldiers but also for conducting

targeted health examinations and for adjusting the programme of physical training and promotion of healthy lifestyles, both for regular and reserve elements of the Montenegrin army. Despite progress in the field assessment of the physical fitness of Montenegrin soldiers, all information comes from research by different researchers, with different testing protocols to assess the same abilities and characteristics. Therefore, there is a need, given the specific abilities and characteristics of Montenegrin soldiers, for standardization and consensus, when assessing the physical fitness of this population is in question. For Montenegro, a unique and up-to-date Montenegrin battery of tests would enable long-term monitoring of the physical fitness of Montenegrin soldiers in order to bring adequate and specific policies that should lead to even better ability levels of Montenegrin soldiers and the highest possible level of defence and security of people and property in Montenegro.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

This research received no external funding.

Conflict of interest

The authors declare that there is no conflict of interest.

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