



RELATIONSHIP OF THE NUTRITIONAL STATUS AND HANDGRIP STRENGTH IN MILITARY FLYING MEDICAL PERSONNEL

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Introduction: The aim of the study was to investigate the relationships between nutritional status and handgrip strength (HGS) of Polish military medical flying personnel.

Methods: The study was conducted among all active members of the personnel (71 males, 13 females) in Poland. Nutritional status was assessed by anthropometric and body composition measurements.

Results: Overweight was diagnosed in 47.6% and obesity in 11.9% members. Abdominal obesity was diagnosed in 38.6% of men and 23.1% of women. In women, the mean HGS of the right and the left hand, respectively, was 33.08 ± 3.57 kg and 33.69 ± 2.95 kg. For men, mean HGS of right and left hand were 55.79 ± 7.62 kg and 54.63 ± 7.93 kg, respectively. Furthermore, for men HGS was positively correlated with skeletal muscle mass ($r = 0.39$), lower limb length ($r = 0.33$) and chest circumference measured on inspiration ($r = 0.33$), but not on expiration. There was no significant correlation between HGS, age, and BMI.

Conclusions: Our study adds to the body of evidence demonstrating an alarmingly high proportion of soldiers with diagnosed obesity. Military medical flight personnel had higher mean handgrip strength as compared to reference values in the male group and in the female group in the left hand. Handgrip strength appears to be related to skeletal muscle mass, similarly to other studies in the general population.

Keywords: obesity, overweight, nutritional status, fat mass index, handgrip strength, military flying medical personnel

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INTRODUCTION

Military flying medical personnel consists of doctors, paramedics and nurses. It is involved in rapid transport of injured (sick) soldiers directly from the battlefield, training ground or military training area to the appropriate medical assistance centres. They are divided into Medical Evacuation Teams (MET). They cooperate with Polish Army units as well as with allied units. Their specialized helicopters and military aircraft are capable of transporting the wounded and injured including those in critical condition. They take part in medical evacuations of civilians as well.

Military service in the air is not typical occupation for medics. This work requires from the military flying medical personnel excellent health condition and appropriate psychological predispositions. The stressful nature of the service may be a factor of many health disorders which, combined with an unhealthy diet, may lead to the development of many metabolic disorders, including obesity.

Proper nutritional status is one of the fundamental factors to maintain high psychophysical performance and good health of military flying medical personnel. Although the nutritional status of the organism is influenced by various factors, i.e., genetic, environmental, sociodemographic and psychological [24], it is fundamental to maintain a proper energy balance, i.e., ensuring a balance between the energy and nutritional value of the food consumed and the amount of energy expenditure associated with daily life activities [14].

Anthropometric examinations and non-invasive bioelectrical impedance analysis (BIA) are commonly used to assess nutritional status [12,25,26]. Another increasingly common anthropometric test is the handgrip strength (HGS) test, which is used to assess muscle strength. According to Massy-Westropp et al. [22], the HGS test is a recommended, inexpensive screening test for assessing muscle strength, non-invasive and easy to perform, with reliability and reproducibility of results, which has been confirmed by validations. In light of reports in recent years this test may be useful in predicting a range of adverse health events. A meta-analysis of 42 studies involving more than three million participants confirmed the relationship between declining handgrip strength with overall mortality, heart disease and cancer [36]. In Poland, the average handgrip strength was 44 kg for males and 30 kg for females (non-dominant hand) [20]. However, differences in the HGS between dominant and non-dominant hand are well described [34].

Hand dynamometer tests have been shown to be a useful tool for assessing strength and functional capacity at work in healthcare workers [23]. According to Leong et al.'s study of 139,691 participants in The Prospective Urban-Rural Epidemiology (PURE) study, increased handgrip strength was associated with young age, male gender, high level of education, employment, high level of physical activity, high calorie intake including high protein intake, with height and weight, and arm circumference [20]. The results of the relationship between age and HGS were heterogeneous in this study and varied between countries and ethnicities.

However, it was demonstrated that grip strength may be affected by fatigue. Wiśniowska et al. [34] demonstrated that in a group of 65 female nurses that the handgrip strength was significantly reduced in both hands after 12-h shift work. Similarly, Tomczak and colleagues demonstrated decreases in maximum handgrip strength due to prolonged exercise combined with sleep deprivation [31,32]. Furthermore, it was demonstrated that higher HGS is associated with higher percentage of percent lean body mass [6]. Similarly, hand grip strength was positively related to muscle mass in female and male young healthy Czech and Slovak students [16].

This study aims to investigate the relationships between nutritional status and grip strength of the upper limbs of Polish military flying medical personnel. We expected a positive relationship of HGS with muscle mass.

MATERIALS AND METHODS

Subjects

The measurements were obtained from all members of active military medical flight personnel in Poland, who reported for obligatory, annual anthropometric examinations to the Laboratory of Dietetics and Obesity Treatment at the Military Institute of Aviation Medicine in Warsaw, Poland, as part of their routine medical examinations. All evaluations were completed between January and December 2019. The study group consisted of 84 persons, including 13 women. The group consisted of 16 physicians, 64 paramedics and 5 nurses. The mean age was 37.75 ± 6.78 years (27 - 55 years). Detailed demographics are presented in Table 1.

Institutional Review Board of the Military Institute of Aviation Medicine, Warsaw, Poland retrospectively agreed to use the results for statistical analyses; therefore, signing informed consent

forms was not required (decision no. 9/2021 of August 11th, 2021). All procedures were performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Study design

Nutritional status was assessed by means of anthropometric examinations, with measurements of height and weight, waist, hip and chest circumference measured both on inspiration and expiration. Body mass index (BMI) and body fat distribution index – waist-hip ratio (WHR) were calculated. Waist circumference (WC) alone was also analysed, using the International Diabetes Federation (IDF) criterion [2], which proposes for the European population a cut-off point of 94 cm for men and 80 cm for women.

Body composition was measured using bioelectrical impedance method with the Inbody 370 analyser (InBody, Tokyo, Japan). The degree of overweight and obesity was assessed according to the Body Mass Index (BMI) and body fat content, according to the World Health Organisation (WHO) criteria [9,23].

Body height was measured with a Harpenden Anthropometer (Holtain Ltd, Crosswell, Crymych, Pembrokeshire, UK) to the nearest 1 mm, in standing upright position without shoes. Body weight and body composition were determined after overnight fast.

Handgrip strength (HGS) was measured using a SAEHAN DHD-1 hydraulic medical hand dynamometer (Glanford Electronics Ltd, Scunthorpe,

UK). The subjects performed the measurement in standing position with the hand lowered along the body and with the elbow joint straightened.

Three trials each were performed for the right and left hand, with a momentary rest for muscle relaxation. The grip strength was measured in kilograms. The averaged value of the obtained results for each hand was taken for analysis. The values obtained were compared with reference values for the adult Caucasian population [22]. So far in Poland there are no HGS normative values for the adult population aged < 65 years, only for people > 64 years [34].

In our study, all evaluations were performed in morning hours. The participants were asked not to perform any physically demanding tasks at least three days before the examination [31,32]. The participants were asked to empty their bladders before the study. They were in underwear only.

Statistical analysis

The obtained results were subjected to statistical analysis with PS IMAGO PRO 6 (IBM SPSS Statistics 25). Mean values, medians, minima, maxima, and standard deviations were calculated. To check for differences between gender and anthropometric parameters, body composition and HGS, Mann-Whitney U test and chi-square test were used, where appropriate. Spearman correlations were used to test the relationships between handgrip strength and anthropometric parameters separately in men and in women (due to small number of females and due to inter-gender differences in body composition). The level of statistical significance was taken as $\alpha < 0.05$.

Tab. 1. Anthropometric characteristics of the military medical aircraft crew by gender.

Parameter	Total N=84			Males N= 71			Females N=13			p
	X	SD	Me	X	SD	Me	X	SD	Me	
Age [years]	37.75	6.76	36.50	38.03	6.76	37.00	36.23	6.98	34.00	>0.05
Weight [kg]	80.58	12.91	81.80	80.58	12.91	81.80	58.94	5.60	60.10	<0.001
Height [cm]	175.54	8.23	177.00	177.96	6.28	178.50	163.46	5.84	165.00	<0.001
BMI	25.93	3.08	25.45	26.63	2.63	26.40	22.12	2.54	22.30	<0.001
Waist [cm]	90.41	9.46	91.00	93.19	7.12	92.00	75.46	5.77	77.00	<0.001
Hip circumference [cm]	99.93	4.97	100.00	100.71	4.34	101.00	87.85	4.24	87.00	<0.001
WHR	0.90	0.07	0.91	0.79	0.05	0.80	0.92	0.05	0.92	<0.001
Chest circumference [cm]	103.37	8.09	105.00	105.62	6.09	106.00	91.08	6.51	90.00	<0.001
Chest circumference on inspiration [cm]	107.43	7.85	108.00	109.72	5.76	110.00	94.92	5.65	95.00	<0.001
Chest circumference on expiration [cm]	101.52	7.90	102.50	103.68	5.97	104.00	89.77	6.82	89.00	<0.001

N - number of participants, X - mean value, SD - standard deviation, Me - median, p - result of the Mann-Whitney U test

RESULTS

The vast majority of the subjects were non-smokers (89.3%), with no differences between males and females. Detailed anthropometric characteristics by gender are presented in Table 1. The mean age of respondents was 37.75 ± 6.76 years. Mean BMI of the women was 22.12 ± 2.54 kg/m² and of the men 25.93 ± 3.08 kg/m².

The normal value of body mass index was found in 39.3% of all medics. Overweight, according to BMI, was diagnosed in 47.6% of the participants, and obesity in 11.9% of all medics studied. Among men, obesity was found in 14%; among women, no obese persons were reported. Detailed results are presented in Figure 1.

Based on waist circumference measurements, abdominal obesity was diagnosed in 38.6% of

men and 23.1% of women. However, when using the diagnostic criteria based on total body fat content [16], obesity was diagnosed only in the male group (see Fig.2.). 46.2% of women were characterised by body fat content below the norm. A detailed summary of body composition parameters by gender is presented in Table 2.

The women's mean right handgrip strength was 33.08 ± 3.57 kg and the left handgrip strength was 33.69 ± 2.95 kg. The left handgrip was higher compared to the reference values for women [20]. The obtained value of the mean right and left handgrip of the male subjects was higher compared to the reference values and was 55.79 ± 7.62 kg and 54.63 ± 7.93 kg for the right and left hand respectively (Table 3). Furthermore, as expected,

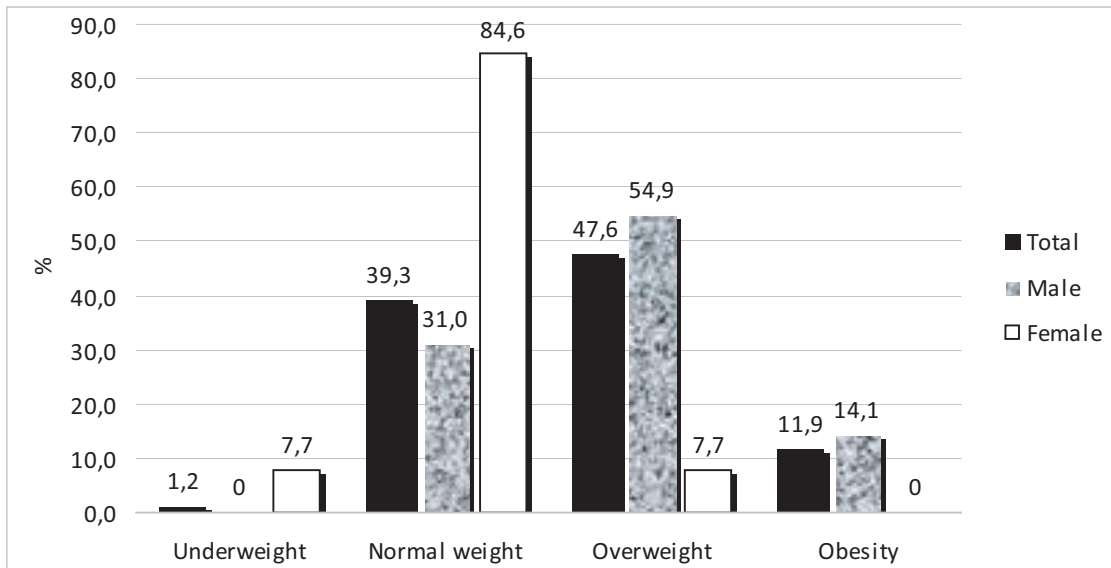


Fig. 1. The prevalence of overweight and obesity in military medical aircraft crew by gender, according to the BMI.

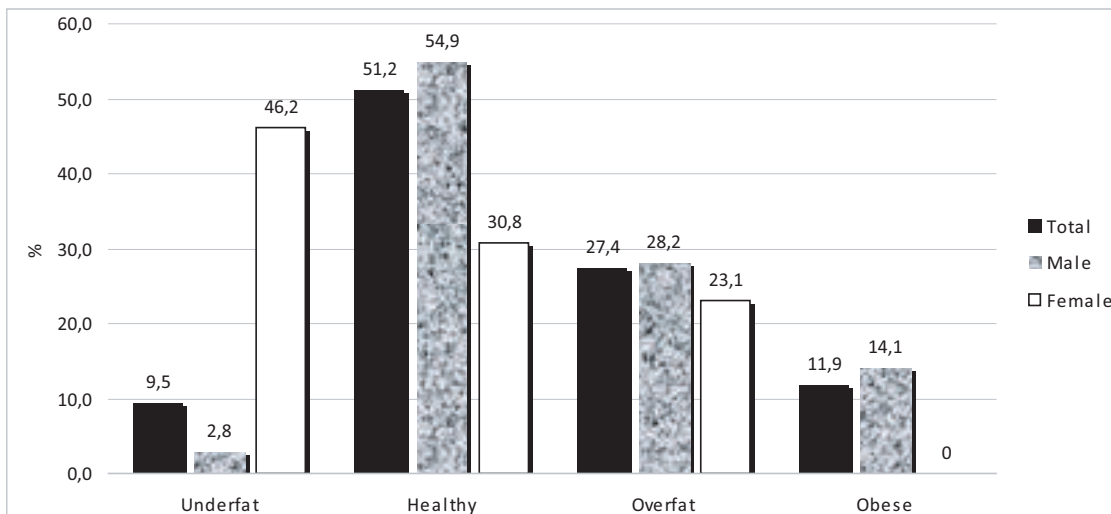


Fig. 2. The prevalence of overweight and obesity among military medical aircraft crew by gender, according to body fat.

Tab. 2. Body composition parameters of military medical aircraft crew by gender.

Parameter	Total N=84			Males N= 71			Females N=13			p
	X	SD	Me	X	SD	Me	X	SD	Me	
TBW [l]	46.85	7.28	48.45	49.32	4.69	48.90	33.36	2.34	32.20	<0.001
Minerals [kg]	4.31	0.70	4.40	4.54	0.50	4.50	3.16	0.26	3.13	<0.001
BFM [kg]	16.46	5.92	14.70	17.06	6.03	16.20	13.45	4.40	13.10	<0.001
SLM [kg]	60.04	9.69	61.50	63.48	6.27	63.00	42.86	3.01	41.30	<0.001
FFM [kg]	64.04	10.02	66.25	67.44	6.45	67.00	45.49	3.23	43.80	<0.001
SMM [kg]	36.17	6.21	37.25	38.39	3.95	38.10	25.07	1.93	24.00	<0.001
PBF [%]	20.31	5.41	20.25	19.92	5.32	19.20	22.44	5.62	21.70	0.119
BMR [kcal]	1743.96	221.30	1776.00	1822.14	144.09	1812.00	1353.08	69.82	1317.00	<0.001

N - number of participants, X - mean value, SD - standard deviation, Me - median TBW - Total Body Water, BFM - Body Fat Mass, FFM - Fat Free Mass, SMM - Skeletal Muscle Mass, PBF Percent Body Fat, BMR - Basal Metabolic Rate, WHR - Waist-Hip Ratio, p - result of the Mann-Whitney U test

Tab. 3. Hand Grip Strength in kilograms, for males and females in relation to standards [6].

Hand grip strength	Males N= 71		Norms for Men 30-39 years		p	Females N=13		Norms for Women 30-39 years		p
	X	SD	X	SD		X	SD	X	SD	
Right hand [kg]	55.79	7.62	47.00	9.70	<0.0001	33.08	3.57	31,00	6,40	0.2502
Left hand [kg]	54.63	7.93	47.00	9.80	<0.0001	33.69	2.95	29,00	6,00	0.0057

N - number of participants, X - mean value, SD - standard deviation, Me - median, p - result of the Mann-Whitney U test

Tab. 4. The results of the correlation of the hand grip strength and other parameters in the group of male.

Parameter	Right hand		Left hand	
	r	p	r	p
Length of the lower limb [cm]	0.33	0.005	0.38	0.001
Chest circumference on inspiration [cm]	0.33	0.004	0.35	0.002
SMM [kg]	0.39	0.001	0.34	0.004
BMI	0.08	0.514	0.04	0.765
Age [years]	0.02	0.836	0.08	0,497

SMM - Skeletal Muscle Mass, BMI - Body Mass Index, p - result of the Mann-Whitney U test

there was a significant difference between hand-grip strength in males and females ($p < 0.001$).

Due to the small number of respondents in the group of women and due to in deniable intergender differences in body composition, the numerical values for correlations between HGS and other variables are presented only for men. Handgrip strength was positively correlated with skeletal muscle mass ($r = 0.39$, $p = 0.001$), lower limb length ($r = 0.33$, $p = 0.005$) and chest circumference measured on inspiration ($r = 0.33$, $p = 0.004$). There was no significant correlation between handgrip strength and age or BMI of the other measured parameters (see Table 4).

DISCUSSION

In this study we evaluated body composition and handgrip strength in all members of military medical flying personnel in Poland. The major finding of this study was a high prevalence of overweight (47.6%) and obesity (11.9%) in this profession. Obesity, according to the WHO definition, was diagnosed only in men. However, abdominal obesity was diagnosed in 38.6% of men and 23.1% of women. Both males and females (left hand) had higher handgrip strength than the reference values for Caucasian population [22], as well as higher compared to the German population, where the average strength of a HGS in women was

estimated at 29 kg for the dominant hand and 27 kg for the non-dominant hand; for men 49 kg and 47 kg respectively in the German population [14]. Significantly lower HGS values were also obtained in Brazilian men [8]. The registered grip strength was 47.6 kg for the right hand; 46.3 kg for the left hand; 47.8 kg for the dominant hand; and 46.1 kg in the non-dominant hand. The authors observed a weak and positive relationship between the dominant hand grip strength and height, weight and BMI.

In our research in male participants, HGS was positively correlated with skeletal muscle mass, lower limb length, and chest circumference measured on inspiration. These correlations were not evaluated in females due to the small size of the group.

The elevated prevalence of overweight and obesity is a characteristic feature of many armed forces of developed countries [1,11,13,15,27-29]. Similarly high results of body mass disorders were obtained by Gałazkowski et al. [8] among Helicopter Emergency Medical Service (HEMS) crews in Poland. Based on BMI analysis, it was demonstrated that more than 40% of HEMS crew members were overweight and over 20% were obese, including 3% of the latter suffering from giant obesity (BMI > 40 kg/m²). In our own study, only those with first degree obesity were reported among medics. Even more disturbing results were obtained by Anand et al. among 160 doctors from Delhi, where the prevalence of obesity was over 40% [3]. In comparison with a study of the nutritional status of military medical flying personnel published 10 years earlier by Kłos and Bertrandt [18], it should be stated that the nutritional status of the entire medical evacuation system (MEDAVAC - Medical evacuation) unit crews has improved over the decade. In the cited study, overweight was then reported in 53.3% of physicians and 61.9% of paramedics, and obesity in 20.0% and 16.7%, respectively.

In our study, the majority (85%) of female military medical flight attendants had normal body weight according to the BMI index. Different results were obtained in studies conducted among Polish, Canadian and Scottish nurses, where the percentage of overweight subjects was 44%, 59% and 69%, respectively [17,19,35]. A study by Kyle et al. [19] on the prevalence of obesity among health professionals in England compared with those who work outside the health service found that compared with nurses, the likelihood of obesity

was significantly lower for other health professionals (adjusted OR 0.52, 95% CI 0.37-0.75) and higher for non - registered care workers (OR 1.46, 95% CI 1.11-1.93) [28]. The authors found no significant difference in obesity prevalence between nurses and non-health professionals (OR 0.94, 95% CI 0.74-1.18).

Studies on the nutritional status of military flying personnel have shown that maintaining normal body weight is a major problem, especially in the male group. Assessment of nutritional status allows us to determine whether the physiological needs of the examined person are fulfilled in relation to their requirements for nutrients. Studies conducted over the years on the nutritional status of Polish Army soldiers show a frequent occurrence of overweight and obesity in this professional group [4,11,13].

Higher HGS in military flying personnel than in general population may have important metabolic meaning, as an inverse association between muscle strength, chronic disease, all-cause mortality, and cardiovascular-related death has been reported [10,21].

Obesity, mainly abdominal obesity, together with muscle function or the relation fat/muscle is a useful tool for predicting CVD, having a summative effect and greater implication than obesity. Thus, the global management and prevention of CVD should include both the control of excess adiposity and maintenance of adequate/high levels of muscle strength.

In our study, there was no significant correlation between HGS and BMI, as well as between HGS and age. There is a discrepancy in the literature regarding the relationship between HGS and BMI. Many researchers claim that there is a positive correlation between HGS and BMI in both sexes and at all ages [5,7,33]. Stenholm et al., [30] who confirmed the association between obesity and HGS decline in a population of 2,021 Finnish people over 55 years of age, showed that people who maintain a body weight within the normal range during their lifetime are not at risk of as rapid a decline in muscle strength as those with chronic obesity.

Limitations

A limitation of the study was the small number of female subjects, only 13. However, these were all professionally active women among military flying medical personnel in Poland at the time of the study.

CONCLUSIONS

Our study adds to the body of evidence demonstrating an alarmingly high proportion of soldiers with diagnosed obesity. Additionally, military medical flight personnel had higher mean handgrip strength as compared to reference values in the male group and in the female group in the left

hand. Finally, handgrip strength appears to be related to skeletal muscle mass, similarly to other studies in the general population. In conclusion, this study described, for the first time, handgrip strength values for the military medical flight personnel in Poland according to nutritional status.

AUTHORS' DECLARATION:

Study Design: Agata Gaździńska, Paweł Jagielski. **Data Collection:** Agata Gaździńska, Marta Turczyńska. **Manuscript preparation:** Agata Gaździńska, Marta Turczyńska, Paweł Jagielski, Stefan Gaździński. The Authors declare that there is no conflict of interest.

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