Relationship between military test scores and obesity-related health risk scores in air defense troops

Alexander Piddubny\textsuperscript{1} ABCE, Serhii Palevych\textsuperscript{1} ABDE, Vitaliy Kyrpenko\textsuperscript{1} ADE, Michael Anthony Martinez Velez\textsuperscript{3} BDE, Federico Anibal Martinez Velez\textsuperscript{4} BDE

\textsuperscript{1}Ivan Kozhedub Kharkiv National Air Force University
\textsuperscript{2}Kyiv National University of Trade and Economics
\textsuperscript{3}Unidad Educativa Naval Comandante Cesar Endara Penaherrera Liceo Naval, Ecuador
\textsuperscript{4}Universidad Nacional Mayor de San Marcos, Lima, Peru

Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

DOI: https://doi.org/10.34142/HSR.2022.08.01.06

How to Cite
Piddubny A, Palevych S, Kyrpenko V, Velez MAM, Velez FAM. Relationship between obesity health risks and the army combat fitness test in the army air defense troops of the ground forces. Health, Sport, Rehabilitation. 2022;8(1):71-84. https://doi.org/10.34142/HSR.2022.08.01.06

Abstract

\textbf{Purpose:} to study the relationship between the results of the Army Combat Fitness Test and the age, gender, body mass index, waist circumference, and health risk index in the military personnel of the Ukrainian army.

\textbf{Design:} The analysis was based on data collected in 2020 for 306 military personnel (255 men and 51 women).

\textbf{Methods:} To compare the number of the Army Combat Fitness Test performed and not performed by military personnel by age, Body Mass Index group, and non-obese and risk groups. Pearson $\chi^2$ test was used. Odds ratios were calculated to assess the risk factors for failing the Army Combat Fitness Test. These analyses were performed depending on gender. Loglinear and Receiver Operating Characteristic – these data were used to determine success within military personnel.

\textbf{Results:} The incidence of non-compliance with the Army Combat Fitness Test in men and women was statistically different in all groups ($p = 0.000$). The results show 23.529\% of male soldiers failed the test. Obese male soldiers did not pass this test (83.333\%) while non-obese soldiers (20.576\%). Among women, the number of those who did not pass the test was 78.431\%. Male and female soldiers classified as "at-risk" had the highest test failure rates (54.255\% and 97.436\%). The observed dependence is statistically significant ($p <0.001$). The relative risk index indicates a direct relationship between obesity and failing the test ($p <0.001$). Loglinear analysis yielded a meaningful model ($\chi^2 (3) = 169.182; p = 0.000$). Wald allows you to determine the statistical significance of individual indicators such as gender. Body Mass Index, risk. These indicators have a great impact on the success of the test. We can talk about a fairly high-quality predictive model with fairly high specificity and excellent classification.

\textbf{Conclusions:} The Army Combat Fitness Test is age-tolerant, and Body Mass Index and Waist Circumference are useful indicators for fitness test results for the Grounded forces.

\textbf{Keywords:} fitness test, military personnel, age, gender, body mass index
Анотація

Олександр Піддубний, Сергій Палевич, Віталій Кирпенко, Майкл Ентоні Мартінес Велез, Федеріко Анибал Мартінес Велез. Взаємозв'язок між результатами виконання армійського тесту та показниками ризику для здоров'я, пов’язаного з ожирінням, у військовослужбовців військ протитанкової оборони.

Мета: вивчити зв’язок між віком, статтю, індексом маси тіла, колом талиї та індексом ризику для здоров’я з армійським бойовим фітнес-тестом (ACFT) у військовослужбовців ППО СВ України.

Дизайн: аналіз був проведений на основі даних, отриманих за 2020 рік для 306 військовослужбовців (255 чоловіків та 51 жінка).

Методи: для порівняння числа випадків виконання і невиконання ACFT військовослужбовцями залежно від віку, групи ІМТ та групи ризику, використовувався критерій χ2 Пірсона. Для оцінки факторів ризику невиконання тесту ACFT розраховувалося співвідношення шансів. Ці аналізи проводились окремо для чоловіків та жінок.

Висновки. Фітнес-тест ACFT толерантний до віку, а ІМТ та ВІТ є корисними індикаторами результатів ACFT для військовослужбовців ППО СВ в Українській армії.

Висновки. Фітнес-тест ACFT толерантний до віку, а ІМТ та ВІТ є корисними індикаторами результатів ACFT для військовослужбовців ППО СВ в Українській армії.

Ключові слова: фітнес-тест, військовослужбовці, вік, статті, індекс маси тіла

Анотація

Александр Піддубний, Сергій Палевич, Віталій Кирпенко, Майкл Ентоні Мартінес Велез, Федеріко Анибал Мартінес Велез. Взаємозв'язок між результатами виконання армійського тесту та показниками ризику для здоров'я, пов’язаного з ожирінням, у військовослужбовців військ протитанкової оборони.

Цель: изучить связь между возрастом, полом, индексом массы тела, окружностью талии и индексом риска для здоровья, связанного с ожирением, у военнослужащих войск противовоздушной обороны.

Методы: для сравнения числа случаев выполнения и невыполнения ACFT военнослужащими в зависимости от возраста, группы ИМТ и группы риска, использовался критерий χ2 Пирсона. Для оценки факторов риска невыполнения теста ACFT рассчитывалось соотношение шансов. Эти анализы проводились отдельно для мужчин и женщин.

Выводы. Фитнес-тест ACFT толерантный к возрасту, а ИМТ и ОТ являются полезными индикаторами результатов фитнес-теста для военнослужащих ППО СВ в Украинской армии.

Ключевые слова: фитнес-тест, военнослужащие, возраст, пол, индекс массы тела
Introduction

Indicators of the level of cardiorespiratory and neuromuscular systems of the body, healthy eating, and weight control, are optimal indicators for the professional fitness of military personnel [1]. Over the past few decades, there has been an increase in the number of overweight military personnel in the Armed Forces of Ukraine. The current system of fitness assessment tests benefits lighter and slimmer military personnel and punishes heavier military personnel, not just thicker ones [2].

On the other hand, larger staff tend to perform better at work-related fitness tasks such as transporting goods, lifting weights, and handling material assets [3]. This was explained by empirical evidence that lean body mass and lean body mass to the deadweight ratio (deadweight = fat mass and external load to be carried/lifted) are more powerful determinants of military performance than fitness test events, such as chin-ups, flexions, and extensions of the arms in the prone position, 100 m, and 3 km runs [4].

Several strategies have been proposed to correct this discrepancy, including a balanced, age-tolerant, and gender-tolerant Army Combat Fitness Test, score scale, and correction factors. At the same time, there is little information about the relationship between these indicators and physical fitness, which needs large-scale verification [4, 5].

This study aimed to investigate the relationship between the results of the Army Combat Fitness Test and the age, gender, standard of weight-for-height (calculated Body Mass Index), and health risk index associated with obesity (measured using Body Mass Index and waist circumference data) in a sample of military personnel of the Ukrainian Army Air Defense Troops of the Ground Forces.

Materials and methods

Study participants

The analysis of data for 2020 was carried out based on information obtained during a depth medical examination according to the methodology for an individual evaluation of the physical development of military personnel of the Armed Forces of Ukraine and control verification exercises on physical training during a pedagogical experiment to test the implementation of NATO standards. All the military personnel were informed about their participation in the research and gave their consent to the systematization and processing of the testing data.

Study organization

The military personnel was weighed to the nearest 0.1 kg using a digital scale (Mi Smart Scales 2, Anhui, China) wearing a T-shirt and shorts, and their height was measured to the nearest 0.1 cm, (PC-2000, GC "Zavet", Kyiv, Ukraine). Waist circumference was measured at the level of the navel (usually the smallest diameter between the costal margin and the chin of the ilium) using an anthropometric tape.

To assess overweight and obesity, the classification of the World Health Organization is used [6]. The classification is based on the definition of Body Mass Index and waist circumference (Table 1). According to this classification, Body Mass Index ≥18.5 <24.9 kg·m⁻² is considered normal, and ≥ 40 kg·m⁻² indicates «morbid» obesity. It is these Body Mass Index figures (25.00-29.99 kg·m⁻² – excess Body Mass Index and Body Mass Index ≥30 kg·m⁻² – obesity) that recommend using, American College of Cardiology / American Heart Association Task Force on Practice Guidelines and The Obesity Society, USA, 2014 [7], Veterans Affairs / Department of Defense, USA, 2014 [8]. National Health and Medical Research Council, Australia, 2013 [9], Academy of Nutrition and Dietetics, USA, 2014, European Endocrine Society, 2015 [10] as a criterion for obesity when screening people > 18 years old to identify adults at increased risk of death.

The Army Combat Fitness Test examines five components of physical fitness - muscle and aerobic endurance. muscle strength, speed/agility, and, explosive strength [11, 12, 13]. The strongest argument for the new test is that it has a high correlation between the Army Combat Fitness Test and ground combat requirements [14]. It does not imply gender or age differences [15].

Participants completed the Army Combat Fitness Test training and testing program during the base period in the military. Participants performed the exercise one by one in the following order:
1. 3 Repetition maximum deadlift;
2. Standing power throw;
3. Hand release push-up – arm extension;
4. Sprint-drag-carry;
5. Leg tuck;
6. Two-mile run.

Exercise number 1. 3 Repetition maximum deadlift
Available in a weight range from 80 to 155 kg. You must complete the maximum deadlift of three reps.
Risk classification of diseases associated with obesity (ICSI 2013, USA)

| Weight estimation       | Body Mass Index. kg/m² | Waist Circumference Men <94 cm | Waist Circumference Women <80 cm | Waist Circumference Men 94 - 101.9 cm | Waist Circumference Women 80 - 87.9 cm | Waist Circumference Men ≥ 102 cm | Waist Circumference Women ≥ 88 cm |
|------------------------|------------------------|--------------------------------|----------------------------------|--------------------------------------|---------------------------------------|----------------------------------|----------------------------------|
| “Underweight”          | <18.5                  |                                 |                                  |                                      |                                       | Moderate risk                     |                                  |
| “Overweight”           | 18.5-24.9              |                                 |                                  |                                      |                                       |                                  | Moderate risk                     |
| “Obesity” class 1      | 25.0-29.9              | Moderate risk                   |                                  |                                      | Moderate risk                         | High risk                        | Extremely High risk               |
| “Obesity” class 2      | 30.0-34.9              | Moderate risk                   | High risk                        |                                      | High risk                             | Extremely High risk               |                                  |
| “Obesity” class 3      | 35.0-39.9              | High risk                       | Extremely High risk              |                                      | Extremely High risk                   |                                  |                                  |

Do three reps with the same weight. If a soldier cannot complete three repetitions, he is allowed to repeat the test once more with a lower weight. If the soldier completes three reps on the first attempt, then he may choose an additional attempt with a higher weight. The maximum number of attempts per 3 Repetition Maximum Deadlift is two.

Exercise number 2. Standing power throw, (Back to the direction of throw and overhead).

The Soldiers will face away from the start line, grasp the medicine ball (4kg) with both hands at hip level, and stand with both heels at (but not on or over) the start line. Grasp the ball firmly and as far around the sides of the ball as possible. The soldiers should be able to throw the ball as far as possible.

Exercise number 3. Hand release push-up – arm extension for 2 minutes.

The soldier begins to perform the exercise in the prone position and do the traditional flexion and extension of the arms in the lying down position, but, being at the lying down position, frees his hands from contact with the ground, put the hands back on the ground, and then perform the next extension.

Exercise number 4. Sprint-Drag-Carry 10 x 25m.

Soldiers stand and sprint 25m; touch the 25m line with foot and hand; turn and sprint back to the start line. Soldiers will grasp each strap handle, which will be positioned and resting on the 75kg sled behind the start line; pull the sled backward until the entire sled crosses the 25m line; Soldiers will grasp the handles of the two 16kg kettlebells and run to the 25m turn line; step on or over the 25m turn line with one foot; turn and run back to the start line.

Exercise number 5. Leg tuck.

Like pull-ups, soldiers raise their legs up and down to touch their knees/hips to their elbows as many times as possible.

Exercise number 6. Two-mile run. 3200 m run.

The run is performed at the command “GO” from a high start on the outdoor track. The running time of the distance is taken into account with an accuracy of 1 sec.

Detailed instructions for testing the Army Combat Fitness Test can be found on the website https://www.army.mil/acft/#overview [16].

**Statistical analysis**

For statistical analysis, participants were categorized according to gender age (< 30 ≥ 30 years old) test score (pass and fail). Body Mass Index (obese ≥ 30 kg·m²; non-obese < 30 kg·m²) and the nice recommendation for health risks associated with obesity (no risk; at risk) (Table 1).

The Pearson χ² test was used to compare the number of cases of the Army Combat Fitness Test accomplish and non-achieve by different categories of military personnel. To assess the risk factors for performing and failing the Army Combat Fitness Test, the odds ratio and relative risk were calculated according to Altman, 1991 [17]. If zeros cause problems with the computation of the odds ratio or its standard error, 0.5 is added to all cells (a, b, c, d) [18]. The association between groups and the success of the test was tested using the «Cochran-Mantel-Haenszel tests». These analyzes were performed separately for men and women, the Army Combat Fitness Test used log-linear analysis. To assess the quality of the logistic regression model, Receiver Operator Characteristic analysis was used, which made it possible to select the model with the best predictive power, analyze the sensitivity and specificity of the models, and select the cut-off threshold.
Statistical significance was assessed with a 95% Confidence interval, analyzes were performed using SPSS version 18, and statistical significance was set at the alpha level of 0.05.

Results

Data were available for 312 military personnel, of whom 195 men and 14 women completed the Army Combat Fitness Test; these figures represent 76.47% and 24.56% of men and women, respectively, of the surveyed sample. Of these, 64.44% of male soldiers and 4.94% of women had «moderate weight» or «overweight» (men: 38.22%, women: 51.85%).

According to the 2006 Nice Body Mass Index classification, 3.56% of men underweight 16 men (7.11%) suffered from obesity and 20.44% are at risk of obesity-related health impairment. Among women, 6.17% suffer from obesity and 53.09% were at risk of health deterioration associated with obesity.

Table 2 shows basic information about the age, gender, and results of the Army Combat Fitness Test of the military personnel of the Ukrainian Army Air Defense Troops of the Ground Forces.

Table 2

| Variable                      | Sub Group       | Male = 255 | Female = 51 |
|-------------------------------|-----------------|------------|-------------|
|                               | N               | %          | N           | %           |
| Age Group                     |                 |            |             |             |
| Up to 25 years                | 161             | 63.14      | 21          | 36.84       |
| Up to 30 years                | 31              | 12.16      | 13          | 22.81       |
| Up to 35 years                | 33              | 12.94      | 16          | 28.07       |
| Up to 40 years                | 30              | 11.76      | 7           | 12.28       |
| Military Status               | Officer         | 12         | 4.71        | 7.02        |
|                               | Sergeant        | 48         | 18.82       | 40.35       |
|                               | Soldier         | 195        | 76.47       | 52.63       |
| Army Combat Fitness Test      | Pass            | 195        | 76.47       | 24.56       |
|                               | Fail            | 60         | 23.53       | 75.44       |

To answer the question of whether age and Body Mass Index groups are associated with the number of cases of accomplishment and non-accomplish of the Army Combat Fitness Test by military personnel, we use the Pearson $\chi^2$ criterion. According to the contingency table (Table 3), the number of non-accomplish cases of Army Combat Fitness Test in men statistically differs in groups aged < 30 years - Body Mass Index ≥ 30 and < 30 ($\chi^2 = 18.500; p = 0.000$), in groups aged ≥ 30 years - no risk and age > 30 years - at risk ($\chi^2 = 62.387; p = 0.000$), in groups of age > 30 years - no risk and age > 30 years - at risk ($\chi^2 = 17.09; p = 0.000$). In women, the non-accomplish incidence of Army Combat Fitness Test is statistically different in the groups age < 30 years - no risk and age ≥ 30 years - at risk ($\chi^2 = 10.76 p = 0.001$).

Table 3

| Group                        | Male | Female |
|------------------------------|------|--------|
|                              | Pass | Fail   | Pass | Fail |
| <30 years - Body Mass Index <30 | 145  | 39     | 9    | 27   |
|                              | 78.8±3.01 | 21.20±3.01 | 23.53±7.22 | 76.47±7.22 |
| <30 years - Body Mass Index ≥30 | 1    | 7      | 1    | 2    |
|                              | 12.5±11.69 | 87.5±11.69 | 33.33±8.08 | 66.67±27.22 |
The results show that while the percentage of male soldiers who failed the test is relatively small (23.53%), the male soldiers who suffer from obesity failed the test more (83.33%) than the soldiers who don’t suffer from obesity (20.58%). This pattern is mostly observed in women. The number of those who did not pass the test is relatively high (75.44%). When the potential risk of obesity-related diseases was considered based on Body Mass Index and waist circumference, male and female soldiers classified as “at-risk” had the highest test failure rates (53.57% vs. 88.24%).

The test risk difference in the < 30 years old group is 66.3% less than in the ≥30 years old group and 51.23% less than in the group at risk of health deterioration due to obesity. In the age group > 30 years, the risk of not completing a test risk difference is also 56.36% lower than in the group Body Mass Index ≥30 and 43.57% lower than in the group at risk of impaired health due to obesity.

The difference between test failure risk difference in female servicemen in the age group < 30 years and > 30 years exposed to risk of impaired health due to obesity and absence risk is 73.93% and 68.24% higher.

Tables 4, 5, 6 and 7 present the results of the risk assessment and the chances of success of the Army Combat Fitness Test in men and women in two age groups. They were divided according to the NICE classification 2006 by Body Mass Index and the risk of health deterioration associated with obesity.

The study showed (Table 4) that the changes in the first group (men under 30) of meeting soldiers who were identified as obese by Body Mass Index among those who did not take the test were 26 times higher than soldiers without signs of obesity. The observed dependence is statistically significant since the 95% Confidence interval does not include 1. The values of its lower and upper boundaries are greater than 1.

The relative risk score indicates a direct link between obesity and the likelihood of test failure. Men who suffer from obesity fail 4.13 times more often than soldiers who don’t suffer from obesity.

### Table 4

| Group | Male | | | | Female | | | |
|-------|------|---|---|---|------|---|---|---|
|       | Test failure rate % (95% confidence interval) | p | Test failure rate % (95% confidence interval) | p |
| < 30 years - Body Mass Index <30 | 21.20 (15.29 - 27.10) | <0.05 | 75.0 (60.85 - 89.15) | <0.05 |
| < 30 years - Body Mass Index ≥30 | 87.5 (64.58 - 110.42) | <0.05 | 66.67 (13.32 - 120.01) | <0.05 |
| Parameter | Parameter value (95% confidence interval) | p | Parameter value (95% confidence interval) | p |
| Odds Ratio on Test Success | 26.03 (3.12 - 217.89) | <0.05 | 0.67 (0.054 – 8.254) | >0.05 |
| Relative Risk associated with obesity | 4.13 (2.82 - 6.05) | <0.05 | 1.31 (1.09 – 1.58) | <0.05 |
In the second group with the risk of obesity (over 30 years of age, men, table 5) are more likely to fail the Army Combat Fitness Test than soldiers with no potential risk (Odds Ratio = 13.09; 95% Confidence interval 1.24-138.11; p<0.05), and failure in the Army Combat Fitness Test occurs in 4.02 times more frequent than among soldiers without signs of obesity (Relative Risk = 4.02; 95% Confidence interval 1.85-8.75; p<0.05).

In the age group of women (over 30 years old), there is no correlation between the probability of the Body Mass Index effect on the chance to pass the test (Odds Ratio = 2.67; 95% Confidence interval 0.24-30.07; p>0.05 and Relative Risk = 1.24; 95% Confidence interval 0.77-1.99; p>0.05).

**Table 5**

Assessment of the risk and chances of success of the Army Combat Fitness Test in the Body Mass Index (with obesity and without obesity) groups in the over-30 years old group

| Group                        | Male                | Female               |
|------------------------------|---------------------|----------------------|
|                              | Test failure rate % (95% confidence interval) | p                        | Test failure rate % (95% confidence interval) | p                        |
| > 30 years - Body Mass Index <30 | 18.64 (8.71 - 28.58) | <0.05               | 69.23 (35.04 - 103.42) | <0.05               |
| > 30 years - Body Mass Index ≥30 | 75 (32.56 - 117.44)   | <0.05               | 85.71 (11.66 - 62.85)   | <0.05               |
| Parameter                    | Parameter value (95% confidence interval) |                          | Parameter value (95% confidence interval) |                          |
| Odds Ratio on Test Success   | 13.09 (1.24 - 138.11)| <0.05               | 2.67 (0.24 - 30.07)     | >0.05               |
| Relative Risk associated with obesity | 4.02 (1.85-8.75)     | <0.05               | 1.24 (0.77-1.99)        | >0.05               |

The same pattern is observed in the third and fourth group with risk of obesity (under and over 30 years old, males, tables 6 and 7). Those who have been identified as being at risk of disease in terms of Body Mass Index and Waist Circumference are more likely to fail the Army Combat Fitness Test than soldiers without potential risk (Odds Ratio = 20.02; 95% of Confidence interval 8.41-47.62; p<0.05 and Odds Ratio = 29.47; 95% of Confidence interval 3.53-246.17; p <0.05). There is a direct correlation between the risk of impaired health associated with obesity and the probability of failure of the test. The results showed that soldiers with no potential risk of disease were more likely to perform the Army Combat Fitness Test (Relative Risk = 9.07; 95% Confidence interval 4.50-18.30; p<0.05 and Relative Risk = 16.25; 95% Confidence interval 2.26-116.79; p<0.05). In the age groups of women (under 30 years old), because of the potential risk of disease in terms of Body Mass Index and Waist Circumference, women are more likely to fail the Army Combat Fitness Test than soldiers without potential risk (Odds Ratio = 87.50; 95% Confidence interval 6.88-1112.32; p<0.05).

**Table 6**

Evaluation of the risk and chances of success of the Army Combat Fitness Test in obesity risk groups (at risk and without risk) in the age group under 30 years old

| Group                      | Male                | Female               |
|----------------------------|---------------------|----------------------|
|                            | Test failure rate % (95% Confidence interval) | p                        | Test failure rate % (95% Confidence interval) | p                        |
| < 30 years – no risk       | 6.35 (2.09 - 10.61) | <0.05               | 22.22 (4.94 - 49.38)  | <0.05               |
| < 30 years – at risk       | 57.58 (45.65 - 69.50) | <0.05               | 96.15 (88.76 - 103.55) | <0.05               |
| Parameter                  | Parameter value (95% Confidence interval) |                          | Parameter value (95% Confidence interval) |                          |
| Odds Ratio on Test Success | 20.02 (8.41 - 47.62) | <0.05               | 87.50 (6.88 - 1112.32) | <0.05               |
| Relative Risk associated with obesity | 9.07 (4.50 - 18.30)     | <0.05               | 4.33 (1.27 - 14.73)   | <0.05               |
The same pattern is observed in the third and fourth groups with the risk associated with obesity (men younger and older than 30). Those identified as being at potential risk of disease in terms of Body Mass Index and waist circumference are more likely to fail the Army Combat Fitness Test than soldiers without potential risk (Odds ratio = 2.667; 95% Confidence interval 0.054 – 0.24 – 40.24; p<0.05, and Odds ratio = 29.467; 95% Confidence interval 3.527-246.165; p<0.05). The results also showed that soldiers without potential disease risk were more likely to perform the Army Combat Fitness Test (relative risk = 2.207; 95% Confidence interval 1.661-2.935; p<0.05, and relative risk = 1.813; 95% Confidence interval 1.279-2.572; p<0.05).

In the age groups of women (under and over 30 years old), those with a Body Mass Index < 30 and ≥ 30 do not have an association between the risk of obesity condition and the likelihood of failure in the Army Combat Fitness Test. Women with a potential risk of obesity condition are 20 and 12 times more likely to fail than women without potential risk. The level of significance of this relationship corresponds to p <0.001.

Log-linear analysis was used to assess the likelihood of military personnel performing the Army Combat Fitness Test. Log-linear analysis performed using the direct step-by-step method (conditional) yielded the final significant model ($\chi^2 (3) = 169.182; p = 0.000$). Wald statistics allows you to determine the statistical significance of individual indicators such as gender ($\chi^2$ Wald = 22.706; p = 0.000), Body Mass Index group ($\chi^2$ Wald = 4.004; p = 0.045), risk ($\chi^2$ Wald = 63.748; p = 0.000), which have a significant impact on the success of the test. The variable age was not included in the model.

The results of the evaluation of the models are given in Table 8. The quality of the binary logistic model was assessed using measures of the model's correspondence to the initial data and according to the classification table and pseudo-coefficients of determination Cox & Snell $R^2$ and Nagelkerke $R^2$. The values of Cox's and Schell's pseudo-$R^2$ and Nagelkerke's pseudo-$R^2$ are 0.425 and 0.592, respectively, from which it follows that the explanatory power of the model is quite high.

### Table 7

| Group                        | Male                        | Female                       |
|------------------------------|-----------------------------|------------------------------|
|                              | Test failure rate % (95% CI) | p               | Test failure rate % (95% CI) | p               |
| > 30 years – no risk         | 2.86 (2.66 – 8.38)          | <0.05                        | 20.00 (0.24 – 40.24)          | <0.05                        |
| > 30 years – at risk         | 46.43 (27.96 – 64.90)       | <0.05                        | 80.00 (44.94 – 115.06)        | <0.05                        |
| Parameter                    | Parameter value             | Parameter value              |
| Odds Ratio on Test Success   | 29.47 (3.53 - 246.17)       | <0.05                        | 56.00 (2.83 – 1109.43)        | <0.05                        |
| Relative Risk associated with obesity | 16.25 (2.26 - 116.79) | <0.05                        | 4.67 (0.80 – 27.08)           | >0.05                        |

### Table 8

| Variables      | B          | Standard Error | Wald     | Value     | Exp (B)  |
|----------------|------------|----------------|----------|-----------|----------|
| Gender         | -2.318     | 0.486          | 22.706   | 0.000     | 0.099    |
| Body Mass Index| 1.591      | 0.795          | 4.004    | 0.045     | 4.910    |
| Risk           | 3.153      | 0.395          | 63.748   | 0.000     | 23.414   |
| Constant       | -0.751     | 0.479          | 2.456    | 0.117     | 0.472    |
The classification table (Table 9) shows that according to the constructed model, it was possible to correctly predict the test execution or failure for 79.4% of the samples. Moreover, this model works better for predicting a negative result, since, in the group of those who did not complete the test, 91.0% of respondents were correctly classified, in the group who did it - 73.8%.

### Table 9

| Observed values | Predicted values | Correct classification percentage |
|-----------------|------------------|----------------------------------|
| Test execution: |                  |                                  |
| No              | 91               | 91.0                             |
| Yes             | 54               | 73.8                             |
| For the sample as a whole | | 79.4 |

Another measure of the quality of the logistic model is the so-called Receiver Operating Characteristic curve (Figure 1).

Based on the expert scale for the values of the area under the curve (AUC = 0.890), we can talk about a fairly high-quality predictive model with fairly high specificity and excellent classification.

**Fig. 1. Receiver Operating Characteristic curve for the success rate of the Army Combat Fitness Test**

**Discussion**

The outcome of the study between the Army Combat Fitness Test results and the age, gender, body mass index, waist circumference and health risk index in the Ukrainian grounded armed forces shows that the Army Combat Fitness Test is age tolerant and the Body Mass Index. waist circumference are important indicators for the Ukrainian Air Force.

The effect of weight status on the results of the Army Combat Fitness Test in the Ukrainian Army Air Defense Troops of the Ground Forces, was investigated the success of the Army Combat Fitness Test in those who met or exceeded Body Mass Index standards (Table 3). Analysis of our participants (data not shown) showed that from the overweight soldiers (94 men; 41 women), only 51 men and 39 women did not pass the individual components of the Army Combat Fitness Test and, Accordingly, did not pass the Army Combat Fitness Test. Most of these male Army Combat Fitness Test failures were in the Leg tuck and the Two-mile run. Analyzing the results of female military personnel, it should be noted that the lowest results are shown in the 3 Repetition Maximum Deadlift exercise, while 76% did not fulfill the threshold level. In the Standing Power Throw exercise, 41% showed results below the threshold level. The most difficult exercise is Leg Tuck (97.2% failure). Failure in strength training is because, due to sexual dimorphism, response to occupational tasks and specific strength training results in greater variability in muscle hypertrophy [19]. The body composition of male and female soldiers can be different, even if the physiological stressors are the same [20].

The data raises concerns that the CrossFit test is difficult for women. Therefore, it is necessary to strive to achieve physical performance through special strength training. However, unlike their male counterparts, female soldiers may not respond to physical stressors with the same level of lean muscle mass development even as they gain strength, creating different relationships between body composition and performance, and the Army Combat Fitness Test should have an alternative to the Leg Tuck an exercise as a Plank [21].

This study found that although the failure rate is low for the Army Combat Fitness Test, especially for male soldiers with a normal Body Mass Index or defined as overweight, the failure rate is markedly increased in the population who suffer from obesity and the risk of deteriorating health associated with obesity.

Our data show that a higher Body Mass Index is associated with improved physical performance such as muscle strength and strength endurance. We confirm the results of Pierce et al., (2017) [3] on the need when assessing readiness for combat training activities, to take into account the trade-offs between groups with different Body Mass Index.
indexes and physical efficiency in tests/tasks of great military importance.

Therefore, using only one Body Mass Index is not always justified, because certain Body Mass Index thresholds may exclude people who do well in certain physical exercises, and Body Mass Index does not affect their functional performance when performing specific military tasks. At the same time, emphasizing the importance of considering Body Mass Index as an important aspect of the general condition/readiness of military personnel, it is necessary to take into account the percentage of body fat as a criterion for obesity by measuring the waist circumference taking into account gender [22].

When the potential risk of obesity-related diseases was considered based on Body Mass Index and waist circumference [23, 24, 25] female soldiers categorized as at-risk have the highest test failure rate (96.15%). These data support the findings of previous studies that Body Mass Index may be more effective in identifying overweight female soldiers than men, and that relative reductions in muscle mass contribute to higher failure rates in female soldiers who suffer from obesity when performing weight transfer tasks [19, 26].

For men and women in every age group, military personnel older and those who suffer from obesity were more likely to fail the test. The relationship between age and obesity [27], decreased cardiorespiratory fitness [28] and general fitness [29] have been well researched. Military research has shown that the change from active work roles to more sedentary management jobs associated with age can reduce activity levels and cause changes in body composition [30]. However, in addition to any changes in occupational physical activity, it is well known that skeletal muscle and strength decrease with age [31], as does maximal aerobic capacity [32], and these changes occur in both untrained and (to a lesser extent) trained people [33]. It should be noted that men who suffer from obesity fail 6.3 times more often than non-obese soldiers. Women with a potential risk of disease are 20 and 12 times more likely to fail than women without potential risk.

Research in NATO military forces has linked physical performance to weight, suggesting that personnel who suffer from obesity pose a high level of risk to productivity [34] and career advancement [35]. Another study concluded that Body Mass Index was the single most important factor in predicting poor fitness test scores [36]. Obesity is also associated with trauma in the military [37].

At the same time, a recent meta-analysis of 5 randomized trials revealed an association of obesity, as measured by Body Mass Index, with coronary heart disease and diabetes mellitus [38]. In a study by D. Lyall et al., (2017), it was found that an increase in Body Mass Index by one standard deviation is associated with an increased risk of developing hypertension, a higher level of systolic and diastolic blood pressure, regardless of age, gender, alcohol consumption and smoking [39].

Further research on this topic has shown that body composition, rather than body weight, is more closely related to metabolic requirements for heavy-duty transport tasks performed by the military [40]. Based on the data given in the table 8, it can be noted that the health risk factor associated with obesity increases the chance of test failure by 23.4 times. It should be noted that despite the low statistical significance of the Body Mass Index, the calculations allow us to note its significant role in increasing the chances of failure of the test (4.9 times). The factor "gender" showed a statistically significant relationship with the resulting trait, however, its presence among the other variables at this stage increases the chances of failing the test by less than 1%. The model has fairly high-quality predictive properties with fairly high specificity and excellent discrimination. The presented model works better for predicting military personnel who did not complete the test (classification accuracy is 91.0%). In a detailed examination, the results obtained can be used as a basis for the development of a complex differentiation about the requirements for the body composition of the air defense servicemen of the Armed Forces of Ukraine Air Force about the requirements for other servicemen.

Thus, using the logistic regression toolkit, it is possible to estimate the likelihood of an increase in the chances of test failure depending on the evaluation of overweight and obesity carried out during an in-depth medical examination, which indirectly reflects the effectiveness of the tools used to stimulate an increase in the level of combat training.

This is important in this case, when, in the Armed Forces of Ukraine, there is a reduction in the number of military personnel and the inability to determine the level of physical fitness at the individual level will have consequences for the collective potential.

The model has fairly high-quality predictive properties with fairly high specificity and excellent classification. The presented model works better for predicting military personnel who did not complete the test (classification accuracy is 91.0%). Our data suggest that the requirements for the body composition of air defense personnel of the Ukrainian Army Air Defense Troops of the Ground Forces, should differ from the requirements for other military personnel. This is important in this case, when, in the Armed Forces of Ukraine, there is a
reduction in the number of military personnel, and the inability to determine the level of physical fitness at the individual level will have consequences for the collective potential.

Conclusion

The Army Combat Fitness Test is age-tolerant, and Body Mass Index and Waist Circumference are useful indicators for fitness test results for Ukrainian Army Air Defense Troops of the Ground Forces.

Conflicts of interest

The authors declare that they have no competing interests.

References

1. Fogelholm M. Malmberg J. Suni J. Santinala M. Kyröläinen H. Mäntysaari M. Waist circumference and BMI are independently associated with the variation of cardio-respiratory and neuromuscular fitness in young adult men. International Journal of Obesity. 2006 Jan;30:962–969. https://doi.org/10.1038/sj.ijo.0803243
2. Paul M. Vanderburgh. EdD. Nicholas S. Mickley BS. Philip A. Load–Carriage Distance Run. and Push-Ups Tests: No Body Mass Bias and Occupationally Relevant. Military Medicine. 2011 Sep;176(9):1032–1036. https://doi.org/10.7205/MIL.MED-D-11-00069
3. Pierce JR. DeGroot DW. Grier TL. Hauret KG. Nindl BC. East WB. et al. Body mass index predicts selected physical fitness attributes but is not associated with performance on military relevant tasks in U.S. Army Soldiers. Journal of science and medicine in sport. 2017 Nov;20(4):79–84. https://doi.org/10.1016/j.jsams.2017.08.021
4. Vanderburgh. Paul M. Occupational Relevance and Body Mass Bias in Military Physical Fitness Tests. Medicine & Science in Sports & Exercise. 2008 Aug;40(8):1538–1545. DOI: 10.1249/MSS.0b013e31817323ee
5. Palevych S. Kyrpenko V. Piddubny A. Bozhko S. Tzymbaliyk Zh. Michael Anthony Martinez Velez. et al. Structural validity of the physical fitness test battery. Health. Sport. Rehabilitation. 2021Dec;7(4):84-97. https://doi.org/10.34142/HSR.2021.07.04.07
6. WHO. World Health Organization: Obesity and overweight. facts and figures. [On-line].: 2020. Available at: https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight
7. Jensen MD. Ryan DH. Aposian CM. Ard JD. Comuzie AG. Donato KA. et al. 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. Journal of the American College of Cardiology. 2014 Jul;63(25):3029-303. https://doi.org/10.1016/j.jacc.2013.11.004
8. Management of Overweight and Obesity Working Group. VA/DoD clinical practice guideline for screening and management of overweight and obesity. Washington (DC): Department of Veterans Affairs. Department of Defense. 2014:178.
9. National Health and Medical Research Council. Clinical practice guidelines for the management of overweight and obesity in adults. adolescents. and children in Australia. Melbourne (Australia): National Health and Medical Research Council. 2013:202.
10. Academy of Nutrition and Dietetics. Adult weight management evidence-based nutrition practice guideline. Chicago (IL): Academy of Nutrition and Dietetics. 2014
11. Kenny GP. Groeller H. McGinn R. Flouris AD. Age. human performance. and physical employment standards. Applied physiology. nutrition. and metabolism. 2016 Jun;41(6):92–107. https://doi.org/10.1113/appmn.2015-0483
12. Palevych SV. Piddubny OG. Tkachuk OA. Zolochevsky VV. The state of the problem and directions for improving the special physical training of servicemen of the Air Force of the Armed Forces of Ukraine. Sportyvna nauka Ukrayini. 2018;1(83):15-25. snu.ldufk.edu.ua
13. Norwegian Armed Forces. Physical requirements for education and service in the Armed Forces. 2020. Available from: https://forsvaret.no/fysiskekrav
14. US Army Public Health Command. Public Health Report No. 12-02-0614. Correlations Between Physical Fitness Tests and Performance of Military Tasks: A Systematic Review and Meta-Analyses. Prepared by Hauschild KD. DeGroot D. Hall S. et al. Aberdeen Proving Ground (MD): USAPHC. 2014. Available from: DTIC: http://www.dtic.mil/docs/citations/ADA607688
15. Appendix 2 to Annex A. HQDA EXORD 219-18 [quoted 25.05.2020]. Available from: https://www.army.mil/e2/downloads/rv7/acft/acft_grader_validation.pdf
16. ARMY COMBAT FITNESS TEST 3.0: Exploring a more inclusive scoring assessment. planks stay [quoted 20.04.2021]. Available from: https://www.army.mil/e2/downloads/rv7/acft/acft_grader_validation.pdf
17. Altman DG. Practical statistics for medical research. London: 1991. Chapman and Hall.
18. Pagano M. Gauvreau K Principles of biostatistics. 2nd ed. Belmont. CA: Brooks/Cole. 2000. ISBN: 0534229026 9780534229023 9812435174 9789812435170
19. COL. Karl E. Friedl.Diabetes Technology & Therapeutics. Oct 2004.732-749 http://doi.org/10.1089/dia.2004.6.732
20. Friedl. Karl E. Body Composition and Military Performance—Many Things to Many People. Journal of Strength and Conditioning Research. 2012 Jul;26:87-100. https://doi:10.1519/JSC.0b013e31825ced6c

21. Member services [quoted 24.09.2020]. Available from: https://www.stripes.com/theaters/us/army-appr-approves-fitness-test-exception-for

22. Heinrich KM. Jitmarin N. Suminski RR. Berkel L. Hunter CM. Alvarez L. et al. Obesity classification in military personnel: a comparison of body fat, waist circumference, and body mass index measurements. Military medicine. 2008; 173(1):67–73.

23. Phillips CM. Metabolically healthy obesity: definitions, determinants, and clinical implications. Rev Endocr Metab Disord, 2013; 14:219–227. https://doi.org/10.1007/s11154-013-9252-x

24. Samocha-Bonet D. Dixit VD. Kahn CR. Leibel RL. Lin X. Nieuwdorp M. et al. Metabolically healthy and unhealthy obese—the 2013 Stock Conference report. Obesity reviews: an official journal of the International Association for the Study of Obesity. 2014; 15(9):697–708. https://doi.org/10.1111/obr.12199

25. Seo MH. Rhee EJ. Metabolic and cardiovascular implications of a metabolically healthy obesity phenotype. Endocrinology and metabolism (Seoul. Korea).2014.29(4):427434.https://doi.org/10.3803/EnM.2014.29.4.427

26. Scott PA. Ramabhai L. Comparison of male and female responses to carrying absolute and relative loads while on a three-hour military march. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2000; 44(17): 161-164.

27. Flegal KM. Carroll MD. Ogden CL. Curtin LR. Prevalence and trends in obesity among US adults 1999-2008. JAMA. 2010 Jan; 303(3):235–241. https://doi.org/10.1001/jama.2009.2014

28. Trappe SW. Costill DL. Vukovich MD. Jones J. Melham T. Aging among elite distance runners: a 22-yr longitudinal study. Journal of applied physiology 1985 Jan; 58(1):285–290. https://doi.org/10.1152/jappl.1996.80.1.285

29. Santtila M. Kyröläinen H. Vasankari T. Tiainen S. Palvain K. Häkkinen A. et al. Physical fitness profiles in young Finnish men during the years 1975-2004. Medicine and science in sports and exercise. 2006 Nov; 38(11):1990–1994. https://doi.org/10.1249/01.mss.0000232023.28894.78

30. Helmhout P. Health-related fitness in the Royal Netherlands Army. Contract No.: RTO-MP-HFM-181-P7. Utrecht. 2009

31. Thom JM. Morse CI. Birch KM. Narici MV. Influence of muscle architecture on the torque and power-velocity characteristics of young and elderly men. European journal of applied physiology. 2007 May; 100(5):613–619. https://doi.org/10.1007/s00421-007-0481-0

32. Heath G. W. Hagberg JM. Ehsani AA. Holloszy JO. A physiological comparison of young and older endurance athletes. Journal of applied physiology: respiratory, environmental and exercise physiology. 1981 Sep; 51(3):634–640. https://doi.org/10.1152/jappl.1981.51.3.634

33. Walter M. Bortz IV. Walter M. Bortz IP. How fast do we age? Exercise performance over time as a biomarker. The journals of gerontology. Series A. Biological sciences and medical sciences. 1996 Sep; 51(5):223–225. https://doi.org/10.1093/gerona/51.a.5.m223

34. McLaughlin R. Wittger G. The obesity epidemic: implications for recruitment and retention of defense force personnel. Obesity reviews: an official journal of the International Association for the Study of Obesity. 2009Oct; 10(6): 693–699. https://doi.org/10.1111/j.1467-789X.2009.00601.x

35. Naghii MR. The importance of body weight and weight management for military personnel. Military medicine. 2006 Jun; 171(6): 550–555. https://doi.org/10.7205/milmed.171.6.550

36. Gantt CJ. Neely JA. Villafana IA. Chun CS. Gharabaghi SM. Analysis of weight and associated health consequences of the active-duty staff at a major Naval medical center. Military medicine. 2008 May; 173(5): 434-440. https://doi.org/10.7205/milmed.173.5.434

37. Cowan DN. Bedno SA. Urban N. Yi B. Niebuhr DW. Musculoskeletal injuries among overweight army trainees: incidence and health care utilization. Occupational medicine (Oxford. England). 2011 Jun;61(4):247-252. https://doi.org/10.1093/occmed/kgr028

38. Riaz H. Khan MS. Siddiqi TJ. Usman MS. Shah N. Goyal A. et al. Association Between Obesity and Cardiovascular Outcomes: A Systematic Review and Meta-analysis of Mendelian Randomization Studies. JAMA network open. 2018 Nov;1(7):e183788. https://doi.org/10.7205/jamainetworkopen.2018.3788

39. Lyall DM. Celis-Morales C. Ward J. Illdromitii S. Anderson JJ. Gill J. et al. Association of Body Mass Index With Cardiometabolic Disease in the UK Biobank: A Mendelian Randomization Study. JAMA cardiology. 2017 Aug; 2(8): 882–889. https://doi.org/10.1001/jamacardio.2016.5804

40. Lyons J. Allsopp A. Bilson. J. Influences of body composition upon the relative metabolic and cardiovascular demands of load-carriage. Occupational medicine (Oxford. England). 2005 Apr;55(5):380384. https://doi.org/10.1093/occmed/kqi087
Information about authors

Alexander Piddubny
poddubnyag@gmail.com
https://orcid.org/0000-0003-0957-2788
Ivan Kozhedub Kharkiv National Air Force University.
61023, Kharkiv-23, Sumskaya Street 77/79, Ukraine

Serhii Palevych
junpolpsv@gmail.com
https://orcid.org/0000-0002-8304-1857
Ivan Kozhedub Kharkiv National Air Force University.
61023, Kharkiv-23, Sumskaya Street 77/79, Ukraine

Vitaliy Kirpenko
vital1973fp@gmail.com
http://orcid.org/0000-0003-3682-7352
Ivan Kozhedub Kharkiv National Air Force University.
61023, Kharkiv-23, Sumskaya Street 77/79, Ukraine

Michael Anthony Martinez Velez
mamartinezv25@gmail.com
https://orcid.org/0000-0001-6239-4269
Naval Educational Unit "Comandante Cesar Endara Penaherrera" Naval School, Ecuador, Quito 170111, Ecuador

Federico Anibal Martinez Velez
mfederico_anibalv@hotmail.com
https://orcid.org/0000-0003-3315-2118
Comando de educacion y doctrina del Ejercito Ecuatoriano
Universidad Nacional Mayor de San Marcos. Lima. Peru

Інформація про авторів

Олександр Піддубний
poddubnyag@gmail.com
https://orcid.org/0000-0003-0957-2788
Харківський національний університет Повітряних Сил імені Івана Кожедуба. кафедра фізичної підготовки.
спеціальної фізичної підготовки і спорта. вул. Сумська 77/79. Харків. 61023. Україна.

Сергій Палевич
junpolpsv@gmail.com
https://orcid.org/0000-0002-8304-1857
Харківський національний університет Повітряних Сил імені Івана Кожедуба. кафедра фізичної підготовки.
спеціальної фізичної підготовки і спорта. вул. Сумська 77/79. Харків. 61023. Україна.

Віталій Кирпенко
vital1973fp@gmail.com
http://orcid.org/0000-0003-3682-7352
Харківський національний університет Повітряних Сил імені Івана Кожедуба. кафедра фізичної підготовки.
спеціальної фізичної підготовки і спорта. вул. Сумська 77/79. Харків. 61023. Україна.

Майкл Ентоні Мартінез Велез
mamartinezv25@gmail.com
https://orcid.org/0000-0001-6239-4269
Військово-морський навчальний підрозділ. Військово-морське училище. імені «Командира Сезара Єндара Пенаеррера», Кіто 170111, Еквадор

Федеріко Анібал Мартінез Велез
mfederico_anibalv@hotmail.com
https://orcid.org/0000-0003-3315-2118
Національний університет Сан-Маркос. Ліма. Перу
Информация об авторах

Александр Поддубный
poddubnyag@gmail.com
https://orcid.org/0000-0003-0957-2788
Харьковский национальный университет Воздушных сил имени Ивана Кожедуба. кафедра физической подготовки. специальной физической подготовки и спорта. ул. Сумская 77/79. Харьков. 61023. Украина.

Сергей Палевич
junpolpsv@gmail.com
https://orcid.org/0000-0002-8304-1857
Харьковский национальный университет Воздушных сил имени Ивана Кожедуба. кафедра физической подготовки. специальной физической подготовки и спорта. ул. Сумская 77/79. Харьков. 61023. Украина.

Виталий Кирпенко
vital1973fp@gmail.com
http://orcid.org/0000-0003-3682-7352
Харьковский национальный университет Воздушных сил имени Ивана Кожедуба. кафедра физической подготовки. специальной физической подготовки и спорта. ул. Сумская 77/79. Харьков. 61023. Украина.

Майкл Энтони Мартинез Велез
mamartinezv25@gmail.com
https://orcid.org/0000-0001-6239-4269
Военно-морское учебное подразделение. Военно-морское училище имени «Командира Сезара Эндара Пеньяэррера», Кито 170111, Эквадор

Федерико Анибал Мартинес Велез
mfederico_anibalv@hotmail.com
https://orcid.org/0000-0003-3115-2118
Национальный университет Сан-Маркос. Лима. Перу

This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)

Received: 2021-11-12  Accepted: 2021-12-21  Published: 2022-03-25