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Body composition of female military cadets in a four-year cycle of study

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: Body composition (BC) analysis is carried out to determine the proportion of body components, fat and lean body mass, and the amount of body fluids. Measurement results determine body fat status in situations of health indications (obesity, anorexia, cystic fibrosis, convalescence). Such tests are also used in certain endocrine disorders. BC analysis is also used in healthy individuals (e.g., monitoring the effectiveness of sports training, dietary indications, preventive examinations). The purpose of this study is to know the likely changes in body composition of young women studying at a military academy.

Material & Methods: Thirty female military cadets were studied: average age 19.4 years (range 18 to 22 years). The study was conducted four times, each time at the beginning of the following academic year Body composition assessment of female military cadets was carried out using a professional body composition analyser from Jawon Medical model X – SCAN PLUS 970. The analysis was based on the following indices: body composition (BC); body height (cm); body weight (kg), body mass index (BMI); soft lean mass (SLM); waist to hip circumference ratio (WHR); lean body mass (LBM); mass of body fat (MBF); body cell mass (BCM); skeletal muscle mass (SMM), Phase angle estimate (phase angle) TS, (total score) score index, which informs about body constitution.

Results: The study group could be described as homogeneous. A few female military cadets showed slight obesity or features of malnutrition. Differences in mean BMI scores over a four-year cycle ranged from – 0.5 to 0.3%. The difference of extreme cycles is –0.2%. LBM measurements showed that each cycle the weight of about 68% of the women was within normal limits. Similar results were found when measuring BCM. The protein and mineral content of SLM was a stable quantity over the four-year test cycle. Changes in mean SMM was found to –0.5%. The optimal amount of muscle tissue was found in 70% of the subjects. The proportions of the study women's membership in the above – or below-normal groups are very similar in each cycle. The total score (TS) women's health status indicates that it is at a good level. The average TS in each year of the study exceeded the standard indicating a desirable score (70 points). At all stages of the study, no woman was found with a score lower than 70 points, and a significant number of women surveyed were diagnosed with very good health (95 points). However, in successive cycles of measurement, the average TS scores are getting lower The largest decrease was observed between the 1st and 4th survey (–7.7%).

Conclusions: The results of the study proved that the cellular capacity for metabolic processes of female cadets is normal. These and other research results can be a rationale for women to take a more comprehensive approach to their bodies: planning a balanced diet, undertaking permanent physical activity, maintaining the right proportion of work and rest time, etc. It is also necessary to realize that the correct relationships of BM components and their optimal levels are related to many soldiering skills, which has been empirically proven many times.

Keywords: balanced diet • condition • impedance analysis • obesity

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Obesity – *noun* the condition of being seriously overweight [25].

Balanced diet –*noun* a diet that contains the right quantities of basic nutrients [25].

Anorexia athletica – *noun* compulsive over exercising, often a feature of eating disorders other than anorexia nervosa [25].

Anorexia nervosa – *noun* a psychological condition, usually found in girls and young women, in which a person refuses to eat because of a fear of becoming fat [25].

Convalescence – *noun* gradual return to good health after an illness or medical treatment, or the period spent recovering [25].

Cystic fibrosis – is an inherited disorder that affects the respiratory, digestive, and reproductive systems. It is caused by mutations in a specific ion transporter gene, which leads to a buildup of thick, sticky mucus in the lungs, pancreas, and other organs. This can cause recurrent infections, chronic lung disease, digestive problems, and infertility.

Condition – *noun* **1**. the particular state of someone or something **2**. a particular illness, injury or disorder; ***verb*** to undertake a fitness plan to improve general health, appearance or physical performance [25].

Muscle tissue – *noun* the specialised type of tissue that forms the muscles and can contract and expand [25].

Physical activity – *noun* exercise and general movement that a person carries out as part of their day [25].

INTRODUCTION

Body composition (BC) analysis is carried out to determine the proportion of body components, fat and lean body mass, and the amount of body fluids. Measurement results determine body fat status in situations of health indications (obesity, anorexia nervosa or athletica, cystic fibrosis, convalescence). Such tests are also used in certain endocrine disorders. BC analysis is also used in healthy individuals (e.g., monitoring the effectiveness of sports training, dietary indications, preventive examinations).

Currently, methods using the latest technology are being used to measure BC. Hydrodensitometry, computed tomography, magnetic resonance imaging, isotope dilution method or assessment of total potassium isotope 40 K. The limitation of their mass application is economic considerations. Non-invasive methods that are effective, economical, simple and safe to perform are widely used. One such method is bioelectrical impedance analysis (BIA). The BIA method [1-3] takes advantage of the difference in electrical conduction in the water and fat compartment. It involves measuring the total resultant electrical resistance of the body using a set of surface electrodes connected to a computer analyser and using a current of a certain intensity and frequency.

Proper body weight and balanced BC components affect the quality of daily activities related to work, sports and recreation [4-7]. This issue also applies to those serving in defence formations. Good health and optimal physique can determine the quality and effectiveness of task performance by soldiers and officers. It is therefore expedient to conduct research and monitor this issue in the armed forces and other defence formations [8-13].

The purpose of this study is to know the likely changes in body composition of young women studying at a military academy.

MATERIAL AND METHODS

Participants

Thirty female military cadets were studied: average age 19.4 years (range 18 to 22 years). The study was conducted four times, each time at the beginning of the following academic year. All subjects knowingly participated in the study were healthy, having been previously informed of the purpose and the method used.

Consent for the study was given

Assessment of body composition

Body composition assessment of female military cadets was carried out using a professional body composition analyser from Jawon Medical model X – SCAN PLUS 970. The device uses the method of electrical bioimpedance BIA, *Bioelectrical Impedance Analysis*, for measurements. The measurement is performed using 180μA currents, 1-, 5-, 50-, 250-, 550-, 1000-kHz frequencies, using 8 electrodes. Measurements were made according to the procedures recommended by the device manufacturer (vitako.pl).

The analysis was based on the following indices: body composition (BC); body height (cm); body weight (kg), body mass index (BMI); soft lean mass (SLM); waist to hip circumference ratio (WHR); lean body mass (LBM); mass of body fat (MBF); body cell mass (BCM); skeletal muscle mass (SMM), Phase angle estimate (phase angle) TS, (total score) score index, which informs about body constitution.

According to the WHO guidelines, the index of BMI (kg/m^2) is divided as follows: <18.50 underweight; 18.50-24.99 normal; 25-29.99 overweight; >30 obese.

Statistical analyses

In statistical tests, the arithmetic mean (M), range of variation, standard deviation (SD), minimum (Min), maximum (Max), percentage differences

(%) in the magnitude of changes in the mean between cycles were calculated, degrees of freedom (df), Student's *t*-distribution (t), significance level, probability (*p*), and statistical hypotheses were verified. The minus sign ("–") in front of some % change values is a mathematical consequence of subtracting the observed values between the compared military training cycles. A cluster analysis was performed using Ward's method. Calculations were performed using the Statistica 13.3 package.

The results of BC measurements were mostly related to three levels: good, normal, below normal. To detect structures in the variables determining BC, cluster analysis was used.

RESULTS

LBM measurements showed that each cycle the weight of about 68% of the women was within normal limits. The average LBM measurements across cycles ranged from 45-45.8 kg with a range of 25.3-38.5 kg. A below-normal indication was determined in about 23%, while the norm was exceeded by about 9% of women. The slight percentage decrease in mean LBM in successive measurements (from 0.1 to 1.7%) suggests a slight decrease in LBM (Table 1).

Similar results were found when measuring BCM. The average of measurements ranges from 31.06 to 31.13 kg. The results determine meeting the standard and exceeding it percentage changes in BCM across cycles were found to be very small (0-0.2%). There was no change in BCM between the first and fourth cycles. Range of variation 25.9-37.4 kg (Table 1).

The protein and mineral content of SLM was a stable quantity over the four-year test cycle. The average SLM was 41.9-42.42 kg. which determines the BC component for meeting the required standard. The change in the average value from cycle to cycle ranges from 0.4% to –0.9%. The difference of the extreme cycles is –0.5% (Table 1).

Table 1. Summary of the results of basic anthropological tests and body composition measurements.

Year of study & statistic indicator		Height [cm]	BMI [kg/m²]	Weight [kg]	SLM [kg]	WHR [ratio]	LBM [kg]	MBF [kg]	BCM [kg]	SMM [kg]	PA [°]	Total [points]
1	M	168.6	20.96	59.7	42.3	0.721	45.7	13.93	31.07	25.36	7.3	88.5
	SD	5.14	1.99	7.2	4	0.025	4.43	3.22	2.86	2.42	0.7	5.11
	Min	159	17.7	48.9	34.9	0.68	37.8	8.6	25.9	20.9	5.9	75
	Max	178	25.4	73.1	50.5	0.78	54.6	20.8	36.7	30.3	8.5	95
2	M	168.6	21.03	59.9	42.3	0.722	45.8	13.95	31.13	25.37	7.28	86.6
	SD	5.14	1.95	7.2	3.88	0.028	4.26	3.32	2.79	2.32	0.66	4.44
	Min	159	18	51	35.5	0.68	38.5	9.4	26.1	21.3	6	80
	Max	178	25.9	76	50.8	0.82	55.2	21.9	37.2	30.4	8.4	95
3	M	168.6	20.96	59.6	41.9	0.724	45	13.95	31.06	25.32	7.49	82.3
	SD	5.14	1.97	7.35	4.64	0.028	5.71	3.42	2.82	2.34	0.61	3.35
	Min	159	18.2	49.4	28.2	0.67	25.3	8.2	26.1	21.1	6.4	80
	Max	178	25.7	77.7	51.1	0.79	55.4	22.4	37.4	30.6	8.8	95
4	M	168.6	20.92	59.5	42.1	0.725	45	13.95	31.06	25.23	7.49	81.6
	SD	5.14	2	7.46	3.94	0.032	5.71	3.42	2.82	2.36	0.61	1.44
	Min	159	17.9	49.2	35.6	0.69	25.3	8.2	26.1	21.3	6.4	80
	Max	178	25.5	76.8	50.8	0.80	55.4	22.4	37.4	30.4	8.8	86

HEIGHT body height; **BMI** body mass index; **WEIGHT** body weight; **SLM** soft lean mass; **WHR** waist to hip circumference ratio; **LBM** lean body mass; **MBF** mass of body fat; **BCM** body cell mass; **SMM** skeletal muscle mass; **PA** phase angle

Similar results were observed when measuring SMM. The average weight of SMM during the study period ranged from 25.23 to 25.37 kg. The optimal amount of muscle tissue was found in 70% of the subjects. The proportions of the study women's membership in the above – or below-normal groups are very similar in each cycle The diagnosis of above-normal concerned 12%, while below-normal concerned 18% of women. Changes in mean SMM was found to −0.5%. The loss of muscle mass of female cadets at the end of the study was −0.5% (Table 1).

The results of the study indicated that the body weight of female cadets did not change significantly (0.3% to −0.5%) during their studies at the military academy. The average weight of the female subjects during the research cycle ranged from 59.6 to 59.9 kg. The decrease in body weight values at the beginning and end of the study was −0.2%. Significant, however, is the gap oscillating around 25 kg in each study cycle (Table 2).

The average MBF content of the women studied was essentially unchanged over the four-year period (13.93-13.95 kg). Normal fat mass content was found. In each year of the study, only a few women were diagnosed with low levels of fatness. High, on the other hand, only in three. Differences in fat content between the first and fourth examinations were 0.2%.

According to the criterion WHR adopted, it should be considered that the body shape of women in each year of the study can be classified as a pear-shape. Adipose tissue is primarily distributed around the thighs and hips. This type of fatty tissue distribution is referred to as gluteal-femoral, or gynoid, obesity. Not a single woman was diagnosed with aneroid (apple) type of so-called abdominal obesity (WHR>0.8). In this aspect, the group should be considered homogeneous. Differences in the increments of average WHR scores over a four-year cycle are very small, ranging from 0.1 to 0.5%.

The average PA value (determines, in part, the body's state of health) ranged from 7.28° to 7.49°. No year of the study showed values below 5°, which could be a sign of a medical condition or physical exhaustion. Differences in average PA scores over the four-year cycle range from 0% to 2.9%. The difference between the first and last cycle is 2.6%.

Female cadets were of normal weight (BMI 20.9-21 kg/m^2) throughout the study period. The study group could be described as homogeneous. A few female military cadets showed slight obesity or features of malnutrition. Differences in mean BMI scores over a four-year cycle ranged from −0.5% to 0.3%. The difference of extreme cycles is −0.2% (Table 2).

Table 2. Summary of statistical tests of the differences of BC extreme measurements 30 female military cadets (df 29).

Variable	Difference	SD	t	p	A confidence level	
					-95 %	+95 %
BMI	0.040	1.206	0.182	0.857	−0.410	0.490
WEIGHT	0.110	3.482	0.173	0.864	−1.190	1.410
SLM	0.197	1.098	0.981	0.335	−0.213	0.607
WHR	−0.004	0.028	−0.712	0.482	−0.014	0.007
LBM	0.717	3.551	1.105	0.278	−0.609	2.043
MBF	−0.027	2.550	−0.057	0.955	−0.979	0.926
PA	−0.187	0.628	−1.628	0.114	−0.421	0.048
BCM	0.013	0.912	0.080	0.937	−0.327	0.354
SMM	0.123	0.651	1.038	0.308	−0.120	0.366

BMI body mass index; **WEIGHT** body weight; **SLM** soft lean mass; **WHR** waist to hip circumference ratio; **LBM** lean body mass; **MBF** mass of body fat; **PA** phase angle; **BCM** body cell mass; **SMM** skeletal muscle mass

The total score (TS) adopted for the final assessment of women's health status indicates that it is at a good level. The average TS score in each year of the study exceeded the standard indicating a desirable score (70 points). At all stages of the study, no woman was found with a score lower than 70 points, and a significant number of women surveyed were diagnosed with very good health (95 points). However, in successive cycles of measurement, the average TS scores are getting lower (although good all the time). Average TS values decrease in the range of –0.8 to –7.7 %. The largest decrease was observed between the 1st and 4th survey (–7.7%). On the other hand, an increase in the homogeneity of the study group should be considered favourable. This is evidenced by the decreasing range and standard deviation of successive studies (Table 2).

At the lowest distances, variables containing similar components to some extent are combined:

BMI, SMM-muscle component; WHR, PA-fat tissue and metabolic cell efficiency; SLM, LBM-muscle, organs, blood, water. The next node shows a similar relationship: BMI, SMM with BCM-muscle component with internal organs; WHR, PA with MBF-fat tissue components; SLM, LBM with WEIGHT-muscle, organs, blood, water with body weight. The next node groups variables with muscle components with variables containing adipose tissue. The next linkage links the previous node with variables defining body weight and fatness to some extent. The last node links an agglomeration of variables specifying BM with body height (Figure 1).

DISCUSSION

In terms of basic somatic characteristics, namely height and weight, the women studied were similar to indicators of young women from different socioeconomic groups [14, 15].

Women's health condition as determined by the total score index indicates that it is at a good level. In each year of the study, the TS exceeded 81 points, which is well above the threshold of the desired standard (70 points). Thus, it can be assumed that the impact of the stimuli of the military academy environment positively affects the health condition of female cadets. It should be assumed that the high level of health fitness was also due to the good health of the female

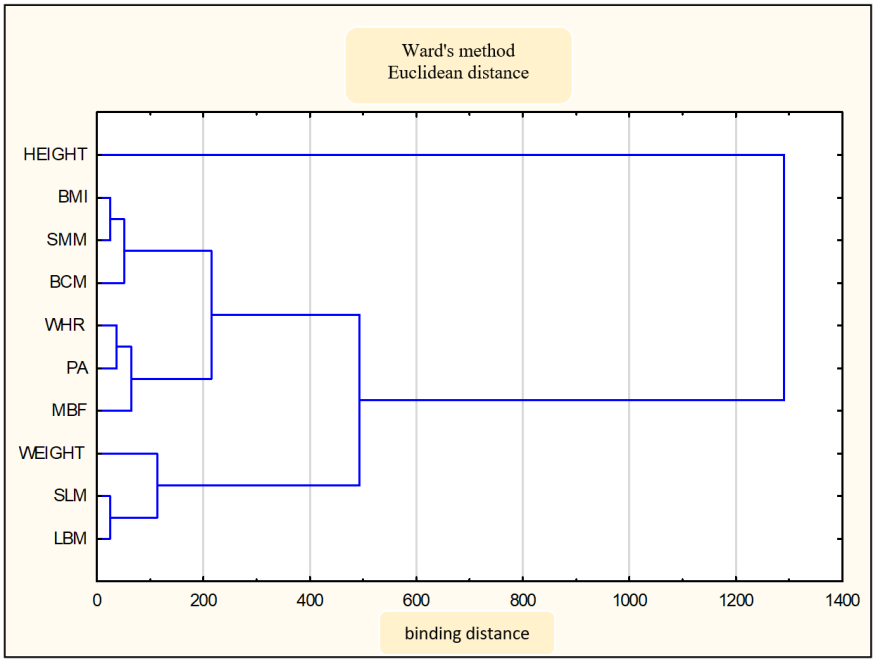

Figure 1. Component connection structure of BC female cadets at the end of the four-year study cycle: **HEIGHT** body height; **BMI** body mass index; **SMM** skeletal muscle mass; **BCM** body cell mass; **WHR** waist to hip circumference ratio; **PA** phase angle; **MBF** mass of body fat; **WEIGHT** body weight; **SLM** soft lean mass; **LBM** lean body mass

candidates at the beginning of the study. Indeed, as part of the academy's recruitment procedures, the Military Medical Commissions pre-screened the health status of candidates [16]. The thesis of the women's good health status is secondarily verified by the results of the component BC studies. The PA results indicated that the women were not at risk for medical conditions and were not physically overtired. Throughout the study period, the women had a normal body weight as determined by the BMI index. Fat and lean body mass were also estimated to be within normal limits.

The overall interpretation of the results of the study leads to the thesis that the body composition of female cadets in the four-year cycle of the study does not change significantly. However, it is possible to indicate a slight tendency to increase body fat mass at the expense of soft tissue and muscle mass.

Analysis of BC derived from agglomeration statistics indicates that all variables had a similar strength of influence on the final BC score. Only the variable „height" shows distinctness and connects to the BC complex by the last node.

It can be presumed that the female cadets' health condition is also due to systematic physical training at the academy. Such classes are conducted throughout the study period at a rate of 4 hours per week. Cadets also pursue military profile classes, which require increased physical activity. These suppositions are confirmed by other studies conducted using the BIA method. They found a correlation of systematically undertaken physical activity at an appropriate intensity on maintaining BMI within normal limits, increasing protein body mass, decreasing body fat content [17-19]. However, it should be mentioned that this method also has its shortcomings [20, 21]. However, this does not undermine the point of correlating BC indicators with other empirical variables – as Huang et al. [22], Litwiniuk et al. [23] among others, do.

CONCLUSIONS

The results of the study proved that the cellular capacity for metabolic processes of female cadets is normal. These and other research results can be a rationale for women to take a more comprehensive approach to their bodies: planning a balanced diet, undertaking permanent physical activity, maintaining the right proportion of work and rest time, etc. It is also necessary to realize that the correct relationships of BM components and their optimal levels are related to many soldiering skills, which has been empirically proven many times [24].

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