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ORIGINAL ARTICLE

ANTHROPOMETRIC AND PHYSICAL EFFICIENCY CHARACTERISTICS OF CANDIDATES NEWLY ADMITTED TO THE POLISH AIR FORCE ACADEMY IN DĘBLIN AS AVIATION PILOT STUDENTS

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Introduction: The objective of the study was to assess the baseline anthropometric parameters and anaerobic efficiency of military pilot candidates in two successive classes admitted to the Polish Air Force Academy in Dęblin.

Methods: The study included all males admitted as aviation pilot students to two successive classes at the Polish Air Force Academy in Dęblin (PAFA). The study group consisted of 35 cadets admitted in 2012 (group I) and 46 cadets admitted in 2013 (group II). The studies were conducted in October 2012 and 2013. The assessment included the measurements of basic anthropometric parameters, bioimpedance evaluation of body composition and evaluation of anaerobic efficiency in a 30-second Wingate test using a Monark 911 SE ergometer.

Results: The mean age in group I was 19.74±1.44 years while the mean age in group II was 19.33±0.99 years. Comparative analysis of anthropometric parameters and body composition revealed no significant differences between the two groups of cadets (P>0.05). The mean percentage fat tissue content in both groups was about 18.5%, fat-free body mass was over 81%, percentage muscle tissue content was 55.3% and the mean body water content was 59.5%. No underweight or obese individuals were identified on the basis of BMI values. Overweight individuals were identified in the study groups (20% of cadets in group I and 10.4 % of cadets in group II). The assessment of anaerobic efficiency revealed no significant differences between groups with the exception of minimum power (P=0.02).

Conclusions: The somatic build of military aviation pilot candidates is similar to the somatic build of civilian university students in Poland. The baseline values of anthropometric parameters and anaerobic efficiency of candidates present a realistic potential for developing proper fitness and efficiency required from military pilots.

Keywords: anaerobic efficiency, anthropometric parameters, body composition, cadets, physical fitness

Tables: 4 • **References:** 27 • **Full-text PDF:** http://www.pjamp.com • **Copyright** © 2014 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

Physical activity, when maintained at an appropriately high level, may ensure good health of individuals. It determines the maintenance of adequate fitness and body efficiency. Appropriate intensity, method, regularity, and duration of physical activity prevent overweight and obesity and ensure appropriate body build and composition.

A rapid increase in the percentage of overweight and obese individuals has been observed in the recent 20 years. Currently, this phenomenon is referred to as pandemic that threatens the entire human population [18]. According to the World Health Organization report, more than one billion people worldwide are overweight, with 30% of that population suffering from obesity [25]. Overweight and obesity are observed across all age groups, including an increasing incidence in children and adolescents [10]. Obesity leads to numerous metabolic complications which may lead to an increased risk of cardiovascular diseases, diabetes, cancer, insulin resistance, lipid metabolism disorders and other diseases [15]. The excess body weight may be due to numerous factors, including genetic, hormonal, psychological or socioeconomic. Studies conducted across the globe suggest that one of the main reasons for the increased percentage of obese individuals is the civilizational progress and the related decrease in physical activity in modern societies [1,2].

Physical activity becomes of particular importance in individuals for whom high motor capabilities, physical efficiency, proper body composition and impeccable health are required for performance of certain occupations aspired after by prospective students. The occupation of a military aviation pilot is a special example of such a situation. Candidates applying for admission to the aviation school are subject to meticulous selection including comprehensive medical, efficiency and fitness tests [8,9]. Such a selection is in force upon the admission of candidates to the PAFA in Dęblin who are to start the long-lasting educational process preparing them to become military aviation pilots.

As shown by the analysis of both Polish and international literature, many air traffic disasters are caused by pilots losing consciousness due to high gravitational loads, including the G-force-induced loss of consciousness (G-LOC) [12,13]. Proper performance of anti-G maneuvers (maneuvers L-1, M-1) is one of the basic measures to prevent such cases [11]. These maneuvers consist in exerting appropriate tension of selected muscle groups at an appropriate moment so as to prevent the outflow of blood from the cerebral cortex and thus the related loss of consciousness. Skeletal muscles may protect that outflow during the anti-G maneuvers due to their ability to accumulate high quantities of energy in the course of anaerobic processes [16]. The main anaerobic processes occurring in working muscles include the hydrolysis of phosphocreatine and glycolysis [23]. Upon extensive effort, such as that during the anti-G maneuvers, body energy supply is completely depleted after about 1-2 minutes in anaerobic conditions. Fast twitch muscle fibers (type IIb) are characterized by a better ability of accumulating energy in anaerobic processes. Individuals with higher percentage of fast twitch muscle fibers are better predisposed for short-term, extensive physical efforts [16]. The ratio of fast-twitch to slow-twitch muscle fibers may be changed by means of appropriate physical training.

Due to appropriate selection of candidates for PAFA students, characterized by impeccable health, appropriately high motor capabilities (in terms of both strength and speed) and anaerobic efficiency [19,21,26] required during anti-gravity maneuvers, the long-term specialized training has the potential to bring forth the desired training results.

The objective of the study was to assess the baseline anthropometric parameters and anaerobic efficiency of military pilot candidates in two successive classes admitted to the Polish Air Force Academy in Dęblin as compared to population of civilian university students and sportsmen with similar fitness and efficiency requirements.

METHODS

The study group consisted of aviation pilot candidates admitted to the Polish Air Force Academy and undergoing training in line with the new curriculum that includes military airplane training after completion of the studies. Previously, military cadets underwent practical military aviation training in an alternating system: they started the training flights after the third semester and continued this training every other (summer) semester while engaging in theoretical studies in odd (winter) semesters.

The studies were conducted in Dęblin following a six-week general military training (adapta-

tion period) in years 2012 and 2013, in October, as a part of routine efficiency tests of PAFA cadets. The study included all males admitted to two successive classes at PAFA:

– group I (35 male cadets) admitted to PAFA in August 2012;
– group II (46 male cadets) admitted to PAFA in August 2013 r.;

All cadets were informed of the range and methodology of the tests and expressed their informed consent to participate in the study. Examinations were performed using non-invasive methods.

The scope of examinations included:

1. Anthropometric parameters: body height and weight. In line with the WHO guidelines, the body mass index (BMI), calculated as the ratio of body mass in kilograms to the squared height in meters, was used to determine the overweight status of subjects [25]. According to the accepted classification, BMI values lower than 18.5 kg/m^2 were indicative of underweight, values in the range of 18.5-24.9 kg/m^2 indicated normal body weight, values in the range of 25-29.9 kg/m2 indicated overweight, while values above 30 indicated obesity [14].
2. Measurements of body mass composition: muscle mass (% MM), fat-free mass (% FFM), fat mass (% FM), total body water (% TBW), basal metabolic rate (kcal BMR) were made by the bioimpedance method using an AKERN BIA101SE body composition analyzer.
3. The assessment of anaerobic efficiency, including the measurement of peak power (PP), average power (AP), minimum power (MP), and power drop (PD) was performed by means of the 30-second Wingate test using a Monark 911 SE cycloergometer. The Wingate test procedure was based on the most popular protocol as proposed by Inbar, Bar-Or and Skinner [5].

Statistical analyses of the results were carried out using the STATISTICA v. 9.0 PL software. The levels of significance for inter-group differences were determined using the Student's t-test for independent variables. The p value of < 0.05 was accepted as the statistical significance level.

RESULTS

The study was conducted in a group of 81 male subjects. Tab. 1. presents somatic build characteristics of groups I and II. The analysis included the following parameters: age, body height, weight and BMI value.

Comparative analysis of age and anthropometric parameters revealed no statistically significant differences between the study groups of male subjects. The mean age in group I was 19.74±1.44 years while the mean age in group II was 19.33±0.99 years. The mean body height, weight and BMI values were very similar. The lower value of SD as observed in group II is indicative of lower inter-subject differentiation as compared to group I.

No statistically significant differences were observed in the analysis of individual body composition parameters compared between both groups of cadets ($p>0.05$). The obtained values were similar as presented in Tab. 2.

The assessment of anaerobic efficiency results revealed no significant differences between groups with the exception of minimum power

Tab. 1. Somatic build characteristics of the subject PAFA cadets.

Index	Group	N	X	SD	Min	Max	Student's t-test	
							t	p
Age [years]	I	35	19.7	1.4	18.0	24.0	1.54	0.13
	II	46	19.3	0.9	19.0	24.0		
BH [cm]	I	35	177.6	5.4	166.5	189.0	-0.03	0.97
	II	46	177.7	4.8	168.5	188.5		
BW [kg]	I	35	73.8	8.3	59.4	96.4	0.43	0.67
	II	46	73.1	6.3	60.5	88.5		
BMI [kg/m^2]	I	35	23.4	2.2	18.4	27.6	0.49	0.62
	II	46	23.2	1.7	18.9	28.2		

Where: N – number of subjects in the group, X – mean, SD – standard deviation, BH – body height, BW – body weight, BMI – Body Mass Index, P – Statistical significance

(P=0.02). The values of individual parameters are presented in Tab. 3.

DISCUSSION

Preparation of military pilots for the performance of combat tasks on modern multipurpose aircraft requires a long-term educational process with the aim of operating the F-16 airplanes that have been recently added to the military equipment of the Polish Air Force. The maneuverability of these airplanes presents new, extreme physiological, physical and mental challenges to pilots [27]. Safe performance of combat tasks is ensured by appropriate fitness and efficiency training combined with high piloting skills.

During the course of their study, each PAFA cadet takes part in the scheduled physical education classes (4 hours, i.e. 180 minutes a week) and sport classes (2 hours, 90 minutes a week). These high-intensity classes are compulsory for all cadets [7,20,22]. Otherwise, the daily routine of cadets includes daily morning physical warm-up of 30 minutes, summing up to additional 150 minutes of organized moderate-intensity physical activity in a week. Overall, this amounts to 420 minutes of organized and supervised physical activity a week. In addition, in their free time, cadets may freely use the PAFA sports facilities and participate in different sports sections. Such organization of the physical educational and sports training provides full potential for the development of motor capabilities and skills by a candidate for multipurpose aircraft pilots throughout the entire five-year study period.

Tests carried out using the International Physical Activity Questionnaire (IPAQ) [17] in 228 students of six public universities in Warsaw (University of Physical Education, Technical University of Warsaw, Warsaw University of Life Sciences, Warsaw School of Economics, Warsaw University and Military University of Technology) showed that only 1.4% of students declared a high physical activity level as compared to 58.6% declaring moderate activity and 36.5% declaring low activity levels [1]. A total of 3.5% of responders declared no regular physi-

Tab. 2. Body composition parameters of PAFA cadets.

Index	Group	N	X	SD	Min	Max	Student's t-test	
							t	p
FM [%]	I	35	18.7	3.5	11.0	27.5	0.20	0.84
	II	46	18.6	3.4	10.0	28.9		
FFM [%]	I	35	81.2	3.5	72.5	89.0	-0.20	0.84
	II	46	81.4	3.4	71.1	90.0		
MM [%]	I	35	56.4	3.4	48.1	61.2	-0.22	0.82
	II	46	55.3	2.8	47.1	60.7		
TBW [%]	I	35	59.5	2.5	53.1	65.1	1.49	0.14
	II	46	59.6	2.5	52.0	65.9		
BMR [kcal]	I	35	1739.5	127.5	1485.8	2103.5	1.346	0.182
	II	46	1708.05	82.54	1558.9	1859.5		

Where: N – number of subjects in the group, X – mean, SD – standard deviation, Min – minimum, Max – maximum, FM – fat mass, FFM – fat free mass, MM – muscle mass, TBW – Total body water, BMR – basal metabolic rate

Tab. 3. Comparative assessment of anaerobic efficiency (Wingate Test) of PAFA cadets of the two tested classes.

Index	Group	N	X	SD	Min	Max	Student's t-test	
							t	p
PP [W/kg BW]	I	37	13.2	1.3	10.6	16.2	0.46	0.64
	II	46	13.4	1.2	10.8	15.7		
AP [W/kg BW]	I	37	8.6	0.5	6.9	9.3	0.89	0.38
	II	46	8.7	0.6	7.5	10.0		
MP [W/kg BW]	I	37	5.3	0.6	3.5	6.2	2.41	0,02*
	II	46	5.6	0.6	4.4	7.0		
PD [W/kg BW]	I	37	7.9	1.4	5.1	10.9	0.70	0.49
	II	46	7.7	1.1	5.3	9.7		

Where: PP – Peak power, AP – Average power, MP – minimum power, PD – power drop, N – number of subjects in the group, X – mean, SD – standard deviation, Min – minimum, Max – maximum, * statistically significant when P < 0.05

cal activity. The mean duration of physical effort was 67.8 min/week for moderate intensity effort and 20.4 min/week for high intensity effort. The discrepancy of the levels of physical activity between the students and civilian universities and the PAFA cadets is very high and amounts to the following numbers:

– moderate activity: 67.8 min/week in civilian university students and 150 min/week in PAFA cadets;
– intense activity: 20.4 min/week in civilian university students and 270 min/week in PAFA cadets.

The somatic build of newly admitted PAFA candidates of two successive classes showed no statistically significant differences in terms of age, body height, body weight and BMI values (Tab. 1.). The results of nutritional status of male students of the first year of 8 civilian universities in Cracow [6] comprising a representative population of all civilian university students were not different from the results of newly admitted PAFA cadets (Tab. 4.).

The results of mean somatic build parameters showed little diversity between the tested groups of students of individual universities and civilian universities overall. When assessing the weight status on the basis of BMI values, both underweight individuals (BMI<18.5) as well as grade II obesity individuals (BMI>35) are encountered among civilian university students. The students of the PAFA, being a carefully selected group, are characterized by lower inter-subject differences and their weight status as determined by their BMI values similar to that of the students of the University of Physical Education. No underweight individuals were identified in the study groups. The percentage of overweight students was 20% and 10.4 % in group I and II, respectively. There were no obese individuals (BMI>30 kg/m2) in either study group. A disturbing increase in the incidence of overweight and obesity determined on the basis of BMI values had been observed in years 1993-2006 among 756,269 US Army recruits at the age of 18 [4]. The incidence of overweight increased from 22.8% in 1993 to 27.1% in 2006 while the incidence of obesity increased from 2.8% to 6.8%.

Body composition (fat and muscle mass) are not included in the BMI being the simplest body weight and height index. Successful passing of the exams by the candidates for PAFA students may indicate that individuals with BMI range typical for overweight who met the qualification criteria had their BMI values increased due to increased muscle mass rather than the increased fat content.

Besides proper health status and body build of aviation cadets, significant information is provided by the analyses and monitoring of body composition that affects the appropriate motor capabilities (strength, speed, dexterity, coordination and efficiency parameters, particularly anaerobic efficiency being essential for aviation pilots). These factors influence the proper fitness and efficiency required while operating military planes, including tolerance to gravitational loads encountered by every pilot during aviation training [8,11,13,24].

As shown by the analysis of the body composition, the mean percentage FFM in both groups of cadets was at the level of 81.25±3.48 % in group I and 81.41±3.37% in group II, which corresponds to the lower range of normal values (Tab. 2.), i.e.

Tab. 4. Somatic build of students of individual universities.

Academy	N	BH	BW	BMI
PAFA group I	35	177.64	73.82	23.44
PAFA group II	46	177.68	73.13	23.22
UE	105	178.10	70.09	22.11
AGH	122	176.64	70.95	22.73
U	115	177.51	72.35	22.95
UA	112	177.55	72.40	22.94
UPE	81	178.88	75.03	23.45
JUMC	100	177.2	71.89	20 71
CUT	111	177.43	70.57	22.42
JU	231	177.88	70.78	22.34
Civilian university students overall	977	177.75	71.63	22.66

Where: N – number of subjects in the group, BH – body height, BW – body weight, BMI – Body Mass Index, UE – University of Economics, AGH – AGH University of Science and Technology, PU – Pedagogical University, UA – University of Agriculture, UPE – University of Physical Education, JUMC – Jagiellonian University Medical College, CUT - Cracow University of Technology, JU – Jagiellonian University

80-85%. Mean TBW values fell within the age-adjusted normal range (50-65%). The percentage FM was 18.75±3.48% in group I and 18.59±2.84% in group II, slightly exceeding the maximum normal values (Tab. 2.), i.e. 15-18% of total body weight.

Individual components of body compositions are correlated between one another. Comparison of the mean values of the analyzed body composition parameters revealed no statistically significant differences between groups. The higher fat mass content led to lower TMW< MM and FFM which in turn depended on socioeconomic conditions, nutritional status and the level of physical activity.

The level of anaerobic efficiency increases over the period of biological growth due to e.g. the increase in muscle mass and strength as well as the increase in the levels of glycolytic enzymes and improved tolerance to acid-base imbalance. As shown by the measurements of the anaerobic efficiency of the first year students at the Polish Air Force Academy, mean maximum power values range between 13.25 and 13.38 W/kg of body weight. Similar measurements of anaerobic efficacy were performed in a group of highly qualified Taekwondo competitors [3]. Individuals practicing this martial art are characterized by motor efficiency profiles similar to those of military pilots (anti-gravity maneuvers, reaction speed, oculomotor and spatial orientation) based on the speed (reaction time, speed of simple and complex movements, movement frequency), dexterity and strength of skeletal muscles. Studies conducted in this group of athletes allowed to define the anaerobic efficiency criteria as being very high (>13.0 W/kg of body weight), high (12.2-13.0 W/kg of body weight), medium (10.6-12.2 W/kg of body weight) and low (<10.6 W/kg of body weight). In the context of these standard values for Taekwondo competitors, the mean peak power (PP) of aviation candidates in group I (13.25 W/kg of body weight) and group II (13.38 W/kg of body weight) (Tab. 3.) is indicative of a very high anaerobic efficiency level in both populations. At the same time, the analysis of the results obtained in PAFA cadets showed that the subject groups also included individuals of low anaerobic efficiency (mi. 10.56-10.80 W/kg of body weight) (Tab. 3.). One may suspect that those individuals were characterized by lower percentage of fast twitch type IIb muscle fibers as compared to type IIa and slow twitch type I muscle fibers [23]. Therefore, despite the fact that these candidates had passed the fitness tests delivered as a part of admission exams, special attention should be paid to such cadets in the process of fitness and efficiency training as a part of their preparation for the occupation of a military pilot.

CONCLUSIONS

1. The somatic build of aviation pilot candidates is similar to the somatic build of civilian university students in Poland.
2. Despite impeccable health and appropriate physical fitness, the groups of aviation pilot candidates included overweight individuals.
3. The baseline values of anthropometric parameters and anaerobic efficiency of candidates present a realistic potential for developing proper fitness and efficiency required from military pilots.

AUTHORS' DECLARATION:

Study Design: Andrzej Stelęgowski, Agata Gaździńska, Marek Kłossowski; **Data Collection:** Andrzej Stelęgowski, Agata Gaździńska, Marek Kłossowski; **Statistical Analysis**: Andrzej Stelęgowski, Agata Gaździńska, Marek Kłossowski; **Manuscript Preparation:** Andrzej Stelęgowski, Agata Gaździńska, Marek Kłossowski; **Funds Collection:** Andrzej Stelęgowski, Agata Gaździńska, Marek Kłossowski. The Authors declare that there is no conflict of interest.

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