

# AN ASSESSMENT OF PHYSICAL EFFICIENCY IN CADET PILOTS BEFORE AND AFTER THE IMPLEMENTATION OF A PROGRAM PREPARING FOR FLIGHTS

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## Abstract

**Objectives:** The aim of the study was to examine the impact of the training program on directed physical fitness. **Material and Methods:** The research involved 35 male cadets of the Polish Air Force Academy in Dęblin. The examined persons were on average 19 years old. All the examined persons were divided into 2 groups. Group I (N = 25, the test group) carried out a program on Special Aviation Gymnastic Instruments. Group II (N = 10, the control group) conducted the standard physical military education program. In both groups, the test was performed twice, before (examination I) and after (examination II) the preparatory process, using the following tests: pull-ups, a 16.5-meter race, a 10×10-meter shuttle race, forward bends, and the Aviation Synthetic Efficiency Test (ASET). The findings obtained in these tests were converted into points for the overall evaluation of physical fitness. The training lasted 70 days. **Results:** In group I, in examination II, there was a statistically significant increase in the results of pull-ups ( $p < 0.01$ ), the 16.5-meter race ( $p < 0.01$ ), the 10×10-meter shuttle race ( $p < 0.05$ ), forward bends for 2 min ( $p < 0.05$ ) and the overall physical fitness ( $p < 0.05$ ), compared to examination I. In group II, in examination II, the authors proved an insignificant increase in the findings when contrasted with examination I. The test results between groups I and II did not show any significant differences in the examined efficiency tests. In group I, in examination I, significant correlations were found between the overall physical fitness and pull-ups, the 10×10-meter shuttle race, the 16.5-meter race, forward bends and ASET. Examination II demonstrated significantly stronger correlations between the overall physical fitness and forward bends as well as ASET. In group II, in examination II, a significant correlation was shown between the overall physical fitness and the 16.5-meter race. **Conclusions:** A significant correlation between the overall physical fitness and ASET in examination II indicates an impact of the training program on the targeted efficiency of the cadet pilots. *Int J Occup Med Environ Health.* 2021;34(5):647–58

## Key words:

physical fitness, examination, training program, Aviation Synthetic Efficiency Test, special aviation gymnastic instruments, targeted efficiency

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## INTRODUCTION

Pilot's physical efficiency is one of the key elements of ground preparation for flights. The period of preparation for flights includes targeted and special training. During the period of targeted training, special attention is drawn to exercises of skeletal muscles involved in the G-strain (the L-1 maneuver). The period of special training is executed after the period of targeted training. It includes Special Aviation Gymnastics Instruments (SAGI) exercises, which consist of looping, gyroscope and the aero wheel, used in shaping spatial orientation, sight-movement coordination, balance and psychomotor efficiency. The design of the above-mentioned instruments and their impact on human body has been demonstrated in a number of studies [1–4]. In the process of pilot training, apart from the general performance, coordination of motor skills also plays an important role. Their basic characteristics include: kinesthetic differentiation, balance, responsiveness, adaptation and adjustment, spatial orientation, coupling (connecting movements), rhythmization and the ability of high frequency movements [5–8]. This is completed with appropriate psychophysical predispositions increasing tolerance to negative flight factors, especially to the occurring accelerations [9,10–14].

The basis for the pilot's job is an appropriate level of neurosensory predispositions, efficiency and physical capacity. For the purpose of targeted training, the Aviation Synthetic Efficiency Test (ASET) has been developed and used for the cadet pilots, containing 16 exercises performed dynamically one by one [1,15,16]. More specifically, ASET involves many muscle groups (lower limbs, upper limbs and the abdomen), which contribute to increasing the tolerance time of high +Gz acceleration values. A maximum tone of these muscle groups prevents blood flow to lower body areas, maintains arterial blood pressure and cardiac output at an appropriate level. The test was developed on the basis of data derived from numerous scientific works, also experimental ones [17–20]. Monitoring movement

co-ordination during the period of targeted training with the use of ASET also gives a foundation for a diagnosis prior to and on completion of special training on SAGI. Scientists still continue to search for a new model of efficiency and performance preparation for an effective implementation of a task in extreme conditions of the pilot's working environment. Many researchers in the field of aviation medicine include the level of strength [18] and strength endurance [17] to factors which counteract +Gz accelerations (the head-feet direction). Coordination abilities are determined genetically to a larger extent. The development of the strength ability and the endurance ability are particularly conflicting in their nature. Their leap development may reduce the formation of almost all coordination abilities. Using maximum loads or those which exceed physical capacity while shaping general physical performance (e.g., in endurance exercises) can be closely linked with a reduction in the level of movement and motor abilities which are indispensable for a pilot [21,22].

The relationship of the load amount with a decrease in movement co-ordination was also observed in other scientific works [23–25]. While the level of motor coordination was known after the period of targeted training, it was not known what that level would be like after special training on SAGI. The nature of the exercises (balance, spatial orientation, coordination) included in ASET formed the basis of its use, both before and after the special training on SAGI. It was, therefore, decided to examine the impact of the implementation of the SAGI training program on targeted physical fitness. The study assesses physical fitness before and after the period of special training on SAGI, taking into account the control group, in order to monitor a correct direction of training for cadet pilots.

The authors formulated a hypothesis that the applied training program on SAGI will improve the efficiency of targeted fitness, measured on ASET, at the end of the training period, in relation to both the initial values and the control group.

## MATERIAL AND METHODS

### Population study

The research involved 35 male cadets, first-year students of the Polish Air Force Academy (PAFA) in Dęblin. The examined persons were on average 19 years old. All the examined persons were divided into 2 groups. Group I included cadets enrolled in the pilot course (N = 25, the test group), who underwent the SAGI training program. In Group II, there were cadets enrolled in the ground course (N = 10, the control group), who completed the standard physical education program of military education.

### Research method

In both groups, the test was performed twice before (examination I) and after (examination II) the preparatory process, using the following tests: pull-ups, a 16.5-meter race, a 10×10-meter shuttle race, forward bends and ASET [15,16]. All the obtained values of the individual tests in both groups were converted into points. The points of these attempts were added in order to make an overall (summary) assessment of the physical efficiency. In each attempt, the following points were determined:

- 14 pull-ups – 200 pts; >200 pts, 1 pull-up equaled 10 pts;
- the result of 2.90 s in a 16.5-meter race – 200 pts, every 0.01 s 5 pts were awarded;
- 29.3 s in a 10×10-meter shuttle race – 200 pts, every 0.1 s scored 3 pts;
- 71 repetitions of forward bends – 200 pts, every forward bend scored 5 pts;
- 49.0 s in the ASET execution – 200 pts, every 0.1 s scored 0.8 pts.

### Assessment of training intensity

The evaluation of intensity and monitoring of training cadets was performed using the POLAR TEAM-2 PRO system for the registration of changes in a heart rate (HR).

### Ethical issues

The consent for the research was given by the Ethics Committee of the Military Institute of Aviation Medicine in Warsaw (decision No. 03A/2009 of July 8, 2009).

### Training program on SAGI

The SAGI group underwent a detailed training program, in accordance with the latest methodology [1]. The activities were conducted in the form of tasks and by repetition, including the methodical highlights of the training process. In the schedule of activities, 60% of the activities constituted learning and improvement of individual exercises on SAGI, 20% focused on learning and mastering team activities on SAGI, and 20% on the proper technique of the exercises.

### Standard training program of physical education

The group underwent general performance workouts, focusing on fundamental motor skills. The authors incorporated team games, field athletics, gymnastics on instruments and swimming. The activities were conducted with high intensity in order to increase the functional capabilities of the body to apply greater loads in further training. During the workouts, the task, repetition and interval methods were used.

In both groups, the period of physical training consisted of 20 two-hour units, implemented within 70 days (twice a week). The cadets had the same conditions of food and accommodation during the training period. The cadets received a standard diet in accordance with the rules of mass catering. The daily food ration, on average, included 4500 kcal, of which 150 g fat (30%), 112.5 g proteins (10%) and 675 g carbohydrates (60%).

### Construction of ASET

The composition of ASET at a distance of 60 m [16]:

- the first circle at a diameter of 1.2 m – distance from the beginning of the hall to the circle centre: 1.70 m,

- 2 circles next to each other at a distance of 2 m from their centre – distance from the beginning to the middle of the circle: 3.0 m,
- mattress 1 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 5.0 m,
- mattress 2 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 7.5 m,
- the gym bench located along the finish line – distance from the beginning to the nearer side of the bench: 12 m,
- mattress 3 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 15.5 m,
- the gym bench located along the finish line – distance from the beginning to the nearer side of the bench: 18.5 m,
- mattress 4 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 22 m,
- 2 medicine balls placed next to each other at a distance of 3 m – distance from the beginning to the line joining the balls: 25 m,
- the weights of 17.5 kg and stand 1 – distance from the beginning: 26 m,
- stand 2 – distance from the beginning: 30 m,
- the first hurdle 63 cm in height – distance from the beginning: 31.5 m,
- the second hurdle 63 cm in height – distance from the beginning: 32.5 m,
- the third hurdle 63 cm in height – distance from the beginning: 33.5 m,
- the fourth hurdle 75 cm in height – distance from the beginning: 37.5 m,
- the fifth hurdle 75 cm in height – distance from the beginning: 39 m,
- the sixth hurdle 75 cm in height – distance from the beginning: 41.5 m,

- the springboard approximately 0.5 m in front of the box,
- the box – distance from the beginning: 50 m,
- mattress 5 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 52.70 m,
- mattress 6 laid out with its longer side towards the finish line – distance from the beginning to the nearer edge of the mattress: 54.70 m,
- the finish line – distance from the beginning of the track (the starting line): 60 m.

### Description of performing ASET [16]

The examined person stands on the starting line and on the command READY enters stand 1, taking the following position: “plank – both feet in the internal circle, the torso in the direction of the axis of the track.” The time is measured from the signal START. The diagram of executing the physical performance course is shown in Figure 1:

- stand 1 – moving the body in the plank position on the external circle to the left or right by approx. 360°; the feet do not exceed the internal circle;
- stand 2 – plank sideways on the left hand in a circle, moving the torso on the feet, in a supported position, 360°, in the anti-clockwise direction;
- stand 3 – plank sideways on the right hand in a circle, moving the torso on the feet, in the supported position, 360°, in the clockwise direction;
- stand 4 – lying on the edge of the mattress, the head held perpendicularly to the track axis to the left, the hands straight along the long axis of the body above the head, rolling the torso to the right along the long axis of the body;
- stand 5 – lying on the edge of the mattress, the head held perpendicularly to the track axis to the right, the hands straight along the long axis of the body above the head, rolling the torso to the left along the long axis of the body;

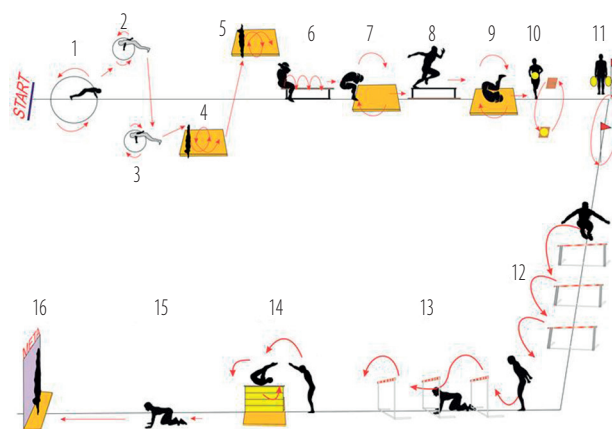
- stand 6 – sitting on the edge of the bench, the hands interlaced at the neck of the torso, triple-shift of the body with feet on the bench towards its other end along the track axis;
- stand 7 – rolling forwards on a mattress;
- stand 8 – running on the reversed bench outside the further support of the bench with a minimum of a double feet contact;
- stand 9 – rolling backwards on a mattress;
- stand 10 – changing the position of 3 kg medicine balls arranged at a distance of 3 m from each other, perpendicular to the track axis;
- stand 11 – running with 2 weights of 17.5 kg around the stands which are set up along the track axis at a distance of 4 m, and placing the weights on the previously marked spot;
- stand 12 – jumping over 3 hurdles, feet together;
- stand 13 – jumping over the first hurdle (feet together), going under the second hurdle and jumping over the third hurdle, feet together;
- stand 14 – running ahead, then rolling forwards on 4 elements of the box;
- stand 15 – running “on all fours” towards the finish line;
- stand 16 – hand standing at the wall – towards the finish line means switching off the time.

### Construction of SAGI

The SAGI training was carried out in an improved version according to the latest technology provided by ETC PZL Aerospace Industries Sp. z o.o. in Warsaw.

### Statistical analysis

In a statistical study, the authors calculated the mean, standard deviation, and Pearson's  $r$  correlation between the variables used in the groups before and after the training process. Normal distribution of all studied variables was checked using the Kolmogorov-Smirnov test. The dif-



**Figure 1.** The Aviation Synthetic Efficiency Test (ASET) diagram (based on [16])

ference between the variables in both groups, tested before and after the preparation period, as well as the difference between the variables between the groups were calculated using Student's t-test for dependent and independent groups. The value of the effect size (power) of physical fitness in tests I and II, in both groups, was calculated by Cohen's  $d$  test for dependent groups, and between groups for independent groups. The statistical analysis of the test results was performed with the use of a statistical program called Statistica v. 9.0. Differences between the mean values are considered significant when the calculated  $p$ -value is  $<0.05$ .

### RESULTS

In the study, it was shown that the body height and weight in group I were statistically significantly higher than in group II, at  $p < 0.0001$  (Table 1). The HR recorded in examinations I and II during the training sessions showed a statistically significant decrease in intensity in group I, at  $p < 0.000001$ , in comparison with group II (Table 1).

In group I, in examination II, the authors demonstrated a statistically significant increase in the results in pull-ups on the bar ( $p < 0.002$ ), the 16.5-meter race ( $p < 0.001$ ), forward bends ( $p < 0.005$ ), ASET ( $p < 0.00001$ ) and the overall physical fitness ( $p < 0.000001$ ) in relation to

**Table 1.** Age, somatic and health rate (HR) data in groups I and II composed of male cadet pilots of the Polish Air Force Academy (PAFA) in Dęblin, Poland

Variable	Group	Participants (N = 35)				P
		examination I		examination II		
		group I (N = 25)	group II (N = 10)	group I (N = 25)	group II (N = 10)	
Age [years] (M±SD)	I	20.7± 1.35	19.2±0.42	20.7± 1.35	19.2±0.42	n.s.
Body height [cm] (M±SD)	I	175.9±4.80*	173.1±5.59	175.9±4.80*	173.1±5.59	n.s.
Body weight [kg] (M±SD)	I	70.4± 6.02*	66.14±6.01	69.6±6.50*	66.15±3.73	n.s.
BMI [kg×m <sup>-2</sup> ] (M±SD)	I	22.8±1.89	22.15±2.04	22.5±2.03	22.14±1.28	n.s.
Training unit HR [bpm] (M±SD)	I	114.5±5.48** <sup>a</sup>	130.0±5.73 <sup>b</sup>	105.4±4.02**	139.8±2.48	

n.s. – non-significant difference.

Group I – test group; group II – control group.

Examination I – before the period of training; examination II – after the period of training.

\* Statistically significant difference compared to group II at  $p < 0.0001$ ; \*\* Statistically significant difference compared to group II at  $p < 0.000001$ .

<sup>a</sup> Statistically significant difference compared to examination II at  $p < 0.000001$ ; <sup>b</sup> Statistically significant difference compared to examination II at  $p < 0.0002$ .

examination I (Table 2). In group II, in examination II, the authors proved a statistically significant increase in pull-ups on the bar ( $p < 0.05$ ), forward bends ( $p < 0.001$ ), ASET ( $p < 0.05$ ) and the overall physical fitness ( $p < 0.001$ ) as compared to examination I (Table 2). In groups I and II, between examinations I and II, the size value of the effect of physical fitness measured with ASET (0.75 and 0.52) in Cohen's d test indicated that the SAGI training program resulted in an improvement in the targeted physical fitness of the cadets compared to the control group (Table 2). Low values of Cohen's d test were found between groups I and II in all physical fitness tests (Table 3). The results between groups I and II did not show significant differences in the examined performance tests (Table 3).

In group I, in examination I, significant correlations were found between the overall physical fitness and pull-ups, the 10×10-meter shuttle race and the 16.5-meter race, in which  $r = 0.72$ ,  $r = 0.72$ ,  $r = 0.73$ , at  $p < 0.0001$ , and between forward bends and ASET, in which  $r = 0.44$

at  $p < 0.05$ , and  $r = 0.48$  at  $p < 0.02$ . In group I, in examination I, significant correlations were found between the pull-ups on the bar and the 10×10-meter shuttle race and the 16.5-meter race, with  $r = 0.40$  and  $r = 0.46$ , at  $p < 0.05$  (Table 4). In examination II, there were clearer correlations between the overall physical fitness and pull-ups, the 10×10-meter shuttle race, the 16.5-meter race, forward bends and ASET, in which  $r = 0.59$ ,  $r = 0.53$ ,  $r = 0.51$ , at  $p < 0.01$ , and ASET, in which  $r = 0.73$  at  $p < 0.0001$ , in relation to examination I (Table 4).

In group II, in examination II, the authors demonstrated a statistically significant increase in the overall physical fitness ( $p < 0.02$ ) in relation to examination I. In group II, in examination I, a significant correlation was found between the overall physical fitness and the 16.5-meter race, with  $r = 0.71$  at  $p < 0.05$ . In examination II, there was a significant correlation between the overall physical fitness and the 16.5-meter race, with  $r = 0.88$  at  $p < 0.005$ , and forward bends, with  $r = 0.74$  at  $p < 0.05$  (Table 4).

**Table 2.** A comparison of physical fitness in examinations I and II between groups I (N = 25) and II (N = 10) composed of male cadet pilots of the Polish Air Force Academy (PAFA) in Dęblin, Poland

Parameter	Score [pts] (M±SD)		Cohen's d test	t	p
	examination I	examination II			
Pull-ups on the bar					
group I	202.40±45.85	229.20±62.31	0.42	-3.53	<0.002
group II	187.00±61.47	222.00±34.57	0.52	-3.15	<0.05
10×10-meter shuttle race					
group I	193.64±28.56	189.08±27.76	0.13	0.90	0.37
group II	190.40±25.72	193.70±28.54	0.10	0.35	0.72
16.5-meter race					
group I	180.2±49.84	210.20±41.62	0.51	-3.82	<0.001
group II	174.50±63.30	218.50±55.92	0.58	1.91	0.10
Forward bends					
group I	207.20±67.20	239.60±68.72	0.39	-3.24	<0.005
group II	193.50±86.76	241.50±73.67	0.47	-4.87	<0.001
ASET					
group I	194.17±36.53	227.35±34.95	0.75	-5.64	<0.00001
group II	203.60±40.89	226.96±26.11	0.52	-2.27	<0.05
Total					
group I	977.61±137.94	1095.43±125.82	0.71	-8.02	<0.000001
group II	949.00±141.29	1102.66±105.50	0.96	-5.22	<0.001

ASET – Aviation Synthetic Efficiency Test.

t – test value.

Explanations as in Table 1.

## DISCUSSION

The obtained results show no significant differences in the somatic characteristics between examinations I and II, in both groups. Besides, no significant difference between the groups was found (Table 1). In group I, the exercises on SAGI improved the results of the overall physical fitness and movement coordination in the cadets, playing a crucial role in the working environment of military pilots. This fact was confirmed by statistically significant results obtained in examination II, in relation to examination I, in the 16.5-

meter race, ASET and the overall physical fitness, illustrated in points. An interesting fact is that the fitness results in group II (control), in examination II, compared to examination I, were better, although they were statistically insignificant. Also, they affected the statistically significant result of the overall physical fitness. By comparing the fitness results between the examined groups, no statistically significant differences were observed.

It is worth stressing that the physical effort in both groups in examinations I and II was implemented in the area of aero-

**Table 3.** A comparison of physical fitness in examinations I and II between groups I and II composed of male cadet pilots of the Polish Air Force Academy (PAFA) in Dęblin, Poland

Parameter	Score [pts] (M±SD)		Cohen's d test	t	p
	group I (N = 25)	group II (N = 10)			
Pull-ups on the bar					
examination I	202.4±45.85	187.0±61.47	0.28	0.81	0.42
examination II	229.20±62.31	222.00±34.57	0.14	0.34	0.73
10×10-meter shuttle race					
examination I	193.64±28.56	190.40±25.72	0.12	0.91	0.75
examination II	189.08±27.76	193.70±28.54	0.16	-0.44	0.66
16.5-meter race					
examination I	180.2±49.84	174.50±63.30	0.10	0.28	0.77
examination II	210.20±41.62	218.50±55.92	0.16	-0.48	0.63
Forward bends					
examination I	207.20±67.20	193.50±86.76	0.17	0.73	0.61
examination II	239.60±68.72	241.50±73.67	0.02	-0.24	0.94
ASET					
examination I	194.17±36.53	203.60±40.89	0.24	-0.66	0.50
examination II	227.35±34.95	226.96±26.11	0.01	0.03	0.97
Total					
examination I	977.61±137.94	949.00±141.29	0.20	0.55	0.58
examination II	1095.43±125.82	1102.66±105.50	0.06	-0.16	0.87

Explanations and abbreviations as in Tables 1 and 2.

bic metabolic changes, which resulted from the measurement of HR values. Demonstrating a significantly lower HR value in group I, in examinations I and II, compared to group II, indicates that the exercises were performed with lower intensity in group I than in group II. At the same time, a statistically significant improvement in motor coordination in group I was observed, as confirmed by the results obtained on SAGI. The lower HR value in group I, in examination II, compared to examination I, proves an adaptation of the cadets to the specific exercises on SAGI and probably a lower response of the circulatory system to the task stress. The exercises on SAGI affect the cen-

tral nervous, muscular and cardiovascular systems through enforced exercises performed in the longitudinal, lateral and sagittal axes. The SAGI exercises affect the receptors of the above-mentioned systems, strengthening the link between the 2 systems responsible for motion: motor and sensors. Therefore, the exercises resulted in an improved concentration, balance and reaction time, and consequently in a better physical fitness and motor coordination shown during the fitness tests in experimental group I. The motor coordination skills were discussed by Szopa et al. [26], who claimed that they specify the body capability in the performance of accurate and precise movements



**Table 4.** Correlations between the physical performance tests conducted before and after the training period in groups I and II composed of male cadet pilots of the Polish Air Force Academy (PAFA) in Dęblin, Poland

Variable	Pearson's correlation			
	group I (N = 25)		group II (N = 10)	
	examination I	examination II	examination I	examination II
<b>Pull-ups on the bar</b>				
vs. 10×10-meter shuttle race	0.40*	0.14	-0.14	-0.20
vs. 16.5-meter race	0.46*	0.10	0.36	0.15
vs. forward bends	0.09	-0.15	0.44	-0.003
vs. ASET	0.36	0.43*	-0.17	-0.49
vs. total number of points	0.72###	0.59***	0.54	0.23
<b>10×10-meter shuttle race</b>				
vs. 16.5-meter race	0.69###	0.20	0.66*	-0.28
vs. forward bends	0.09	0.05	-0.35	-0.66*
vs. ASET	0.32	0.52***	0.76***	0.71*
vs. total number of points	0.72###	0.53***	0.42	-0.23
<b>16.5-meter race</b>				
vs. forward bends	-0.07	-0.15	-0.32	0.56
vs. ASET	0.44*	0.59***	0.64**	-0.07
vs. total number of points	0.73###	0.51***	0.71*	0.88#
<b>Forward bends</b>				
vs. ASET	-0.26	-0.13	-0.22	-0.32
vs. total number of points	0.32	0.26	0.35	0.74*
<b>ASET</b>				
vs. total number of points	0.48**	0.73##	0.50	0.01

R – correlation coefficient.

\* p < 0.05; \*\* p < 0.02; \*\*\* p < 0.01; # p < 0.005; ## p < 0.0001; ### p < 0.000001.

Explanations as in Tables 1 and 2.

in changing external conditions (changes of the movement direction, plane and axis). Among the conducted tests of targeted physical performance in the present studies, special attention needs to be drawn to ASET, which was developed for selection purposes into PAFA [15]. The test diagnosed cadets in the light of their capabilities to adjusting motion activities to variable conditions and situations (orientation), rhythmization, quick reactions and motor adjustment. In the coordination hierarchies of

motor skills, these conditions constitute the top level of control [5]. In the process of targeted training, apart from the listed qualities, ASET was used to evaluate the preparation of an anti-G straining maneuver, affecting those muscle parts, by means of training measures, that were responsible for its proper implementation.

In addition, ASET was used to assess the level of neurosensory predisposition in the pilot cadets during the period of targeted training. After this period, it also qualified them

to start training on SAGI. The research conducted by Wochoński et al. [15] demonstrated that ASET significantly correlated with pull-ups ( $r = -0.25$ ), a 100-meter race ( $r = 0.50$ ) and a 1000-meter race ( $r = 0.23$ ), at  $p < 0.05$ . The observed correlation proves that ASET seems to create complex motor tasks for the candidates. The same studies revealed that the cadets who obtained very good results in the 1000-meter race, the 100-meter race and pull-ups did not have the best time in ASET execution. The optimization of physical load is an important factor in the process of shaping motor coordination. Exceeding the threshold of optimum physical load lowers the coordination ability in the exercising participant. In these studies, the authors applied the exercise program on SAGI [1], whose efficiency was assessed by means of ASET at the end of the training period (examination II), obtaining a statistically significant improvement.

The factor which reinforced the appropriateness of the SAGI training direction to shape spatial orientation and balance was a correlation analysis between ASET and the overall sum of points (the overall physical fitness) in groups I and II, before and after the training period. Namely, in group I, after the training period, it was possible to demonstrate a high correlation between ASET and the general sum of points,  $r = 0.73$ , whereas in group II, it was  $r = 0.01$ . This fact proves that the impact direction of the training process on SAGI was appropriate, whereas in group II a completely different direction of the exercise program was seen, which confirms the significant difference between these correlations. After a 40-hour training session on SAGI, addressed to pilot cadets, there was a statistically significant improvement of the results on ASET in group I, indicating that the exercises on SAGI positively influenced improving and maintaining the targeted physical fitness. This clearly demonstrates that the exercises on SAGI can be effective in improving the tolerance to accelerations +Gz.

The study by Wochoński et al. [27] showed a negative correlation between the total time of rotation on a G-strain cen-

trifuge, the interval characteristics (the so-called time program), and ASET, i.e., the shorter time achieved on ASET, the longer execution time during rotation. The relevance of this correlation depends on the level of targeted efficiency in the cadets. In previous investigations, it was shown that the same exercises on SAGI did not significantly affect the tolerance level of +Gz accelerations. Their efficiency grew after applying breathing isometric exercises (the Valsalva maneuver) [28]. Due to the execution of the majority of physical exercises in the sagittal plane, during ASET execution, it can be concluded that the exercise on SAGI increased stability, consequently leading to significantly statistically better statistical results in ASET execution, in examination II.

## CONCLUSIONS

In this research, the SAGI special training program in group I resulted in a statistically significant increase in the targeted fitness measured with ASET in examination II, compared to study I, and in a statistically insignificant increase compared to group II (control). The comparison of examinations I and II shows that the value of the effect size in ASET, when calculated with Cohen's d test, was higher in group I than in group II. Also in group I, in examination II, a higher statistically significant value of the correlation coefficient than in examination I, between the overall physical fitness and ASET, confirmed the increase in physical fitness of targeted cadet pilots. The SAGI training program was properly applied and improved the targeted fitness compared to group II (control).

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