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The impact of motor predispositions in cadets upon the results of the execution of Aviation-Synthetic Efficiency Test

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

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Abstract

Background and Study Aim: Motor skills are the basis for the selection of cadets for extreme environmental conditions for the pilot's work. Modern military equipment requires an increase in the physical and operator performance from the pilots. Therefore, the Aviation Synthetic Efficiency Test (ASET) was developed, playing a practical role in the evaluation of a physical preparation of pilots and their selection for aviation. The authors assumed that a significant number of cadets who demonstrated endurance – strength skills should achieve the highest speed of executing ASET, which could confirm the diagnostic function of the test dedicated for selection purposes in aviation. In the paper, the authors formulate a hypothesis that ASET timing depends upon motor skills in cadets, including somatic qualities.

Material and Methods: The investigation involved 59 male cadets at the average age of 21 years, studying in the first year of the aircraft pilot course. The average body weight of the examined persons equals 73.8 kg. The cadets were divided into two body weight groups: up to 73.8 kg – group A (n = 30) and above 73.8kg – group B (n = 29).

Results: The average body weight, body height and BMI were statistically significantly different among the examined groups. There was no statistically significant difference among the examined groups in the endurance tests. In the examined groups, was cadets with the following motor skills: endurance-strength type (En-St), endurance-speed type (En-Sp), speed-strength type (Sp-St), speed type (Sp), strength type (St) as well as endurance type (En). The examined persons who had only one dominant motor skill was had poorer results in ASET execution than those with double motor skills, e.g. endurance-strength. Better results were found in cadets with single skills rather than in those with double skills in only two cases. In eleven cadet pilots, the authors found double motor skills of three motor types: En-Sp, En-St, Sp-St.

Conclusions: The speed in ASET execution by the examined persons is closely related to their motor skills (predispositions), which undoubtedly exerts a tremendous practical role in the selection of pilots for military aviation. The investigation demonstrated that in the group of all examined cadets, En-St reached the highest average speed in the execution of ASET, which confirms the usefulness of this test for the selection of future military pilots. In group A the highest speed in ASET execution was achieved by the endurance-speed type, whereas in group B it was achieved by the speed-strength type, which indicates that somatic qualities may be closely related to motor skills.

Key Words: electromyography • motor skills • multidimensional test • survival

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INTRODUCTION

Motor skills are the basis for the selection of cadets for extreme environmental conditions for the pilot's work. Modern military equipment requires an increase in the physical and operator performance from the pilots. The physical fitness of pilots is a permanent part of the preparations for flights, calling for its objective assessment. This assessment should be conducted by means of a motor adjustment test. Therefore, the Aviation Synthetic Efficiency Test (ASET) was developed, playing a practical role in the evaluation of a physical preparation of pilots and their selection for aviation [1]. ASET belongs to the category of motor multidimensional tests (see glossary).

After several years of experience in training and fitness diagnosis, it underwent several modifications [2]. In ASET, the main factor which undergoes evaluation was the level of dynamic work of skeletal muscles involved in executing the anti-strain manoeuvre (manoeuvre L-1) by pilots. On the basis of electromyography testing the muscles used for the manoeuvre L-1 are as follows: m. latissimus dorsi, m. intercostalis, m. buccinator m. sternocleidomastoideus, diaphragm, m. pectoralis major [3] and m. flank femoris, m. flank at m. erector spinae [4].

According to a study by Whinnery [5] a properly executed manoeuvre of flexing skeletal muscles (anti-strain manoeuvre), on average, increases the tolerance of 1-2 G. In the process of pilot training, apart from the general physical fitness, motor coordination skills, spatial orientation, equilibrium, rhythmisation, couplings, response time and psychophysical predispositions exert an important role, as they increase tolerance to negative flight factors, particularly to the occurring accelerations [6-8]. Therefore, the use of ASET was highly justified due to a comprehensive assessment of these features, and at the same time due to determining the professional suitability of aviation cadets. Due to the ASET diagnostic function within the motor adaptation in the pilot's environment. In this study it was authors decided to determine the motor types using the Schele biopsy examination [9]. The basis for the classification of motor types was previous diagnostic tests which demonstrated that persons with prevailing FT muscle fibres (fast twitch fibre) have a predisposition for sprint; whereas persons with dominating ST muscle fibres (slow twitch fibre), have a predisposition for long-distance running [9].

The factor which reinforces the method of classifying motor types also showing a high correlation between maximal oxygen consumption(VO2max) and the content of ST muscle fibres [10]; also a high correlation between VO2 max and the number of mitochondria in muscles [11]. ASET may have a more important selection role than before [1], because previously the motor types among cadets remained unspecified.

Body weight plays a significant role in the classification of motor types. The classification is obtained by subjecting the cadet pilots to the ASET test considering their body weight. This gives us an exact method to determine the motor predispositions for military aviation. Specifying the motor skills is the primary factor for the selection in aviation. The latest investigation of aviation cadets, during a test on a centrifuge, showed that the endurance-strength type proved the most effective [12]. Although we have a tool for evaluating maximum strain tolerance capabilities (centrifuge), there is no practical method of determining the pilot's motor skills, which hinders the choice of aviation candidates.

Motor multidimensional tests – the obstacle course is the most common one. The structure of such tests, as a system of motor tasks (often repeated several times) informs us about muscle strength, speed, agility, whereas test execution time (scheduled for a time from several dozen seconds to even several dozen minutes) indicates endurance (of a specific type) [18].

Psychomotor multidimensional tests – in this group of tests, at least one task is used to diagnose a specific motor skill. Special Judo Fitness Test (SJFT) is a good example. A judo throw seoi nage, repeated for numerous times, is the main element of motor skills used in this test [see 38]. Another example: the first round of UNIFIGHT comprises a special obstacle strip that includes shooting a pneumatic gun or paintball gun and throwing at the target (adults with a sporting knife, children with a tennis ball) [22]. This special obstacle may be used as a psychomotor multidimensional test while learning motor skills (not only for the purposes related to UNIFIGHT) 18].

Motor skills – *plural noun* the ability of a person to make movements to achieve a goal, with stages including processing the information in the brain, transmitting neural signals and coordinating the relevant muscles to achieve the desired effect [38].

Motor – *adjective* relating to muscle activity, especially voluntary muscle activity, and the consequent body movements [38].

Endurance – *noun* the ability or power to bear prolonged exertion, pain or hardship endurance athlete [38].

The authors assumed that a significant number of cadets who demonstrated endurance – strength skills should achieve the highest speed of executing ASET, which could confirm the diagnostic function of the test dedicated for selection purposes in aviation. In the paper, the authors formulate a hypothesis that ASET timing depends upon motor skills in cadets, including somatic qualities.

MATERIAL AND METHODS

Study population

The investigation involved 59 male cadets at the average age of 21, studying in the first year of the aircraft pilot course. The average body weight of the examined persons equals 73.8 kg. The cadets were divided into two body weight groups: up to 73.8 kg – group A (n=30) and above 73.8kg – group B (n=29). All the examined persons underwent the following fitness tests: 40 m race, 100 m race, 1000 m race, 2000 m race and pull-ups (Table1). Next, the authors used the ASET, developed and modified by Wochyński [2], consisting of 16 exercises to be performed at a distance of 60 m. On the basis of the ASET timing, the authors determined the total level of focused motor skills of the Air Force Academy candidates, by combining the individual components of the exercises into one entity.

In both groups of cadets, motor skills types were established by means of the following tests: 40 m race, pull-ups and 2000m race. ASET was constructed in such a way that the applied training assets could mostly affect those muscle groups which are particularly exposed to overloading during stretch manoeuvres. The above test covered all the candidates for professional soldiers who were admitted into the Air Force Academy two weeks after joining up.

The examined candidates had not become familiarized with the test previously, and therefore they executed it without a special preparation. The test results and the running tests of each examined person were converted into speed expressed in meters per second (m/s). Within two weeks, all the cadets had the same living conditions and were given the same food.

Ethical issues

The authors obtained permission of the appropriate ethical commission to perform the study. Consent of the proper bioethical commission for the studies were obtained (decision No. 03A/2009 of 08.07.2009. Ethical Commission on biomedical research studies at the Military Institute of Aviation Medicine in Warsaw, Poland).

Construction of Aviation Synthetic Efficiency Test (ASET)

The composition of ASET at a distance of 60 metres [2]:

- The first circle at a diameter of 1.2 m – the distance from the beginning of the hall to the circle centre equals 1.70 m
- Two circles next to each other at a distance of 2 m from their centre – the distance from the beginning to the middle of the circle equals 3.0 m
- Mattress 1 laid out with its longer side towards the finish line – the distance from the beginning to the nearer edge of the mattress equals 5.0 m
- Mattress 2 laid out with its longer side towards the finish line – the distance from the beginning to the nearer edge of the mattress equals 7.5 m
- The gym bench placed along the finish line – the distance from the beginning to the nearer side of the bench equals 12 m
- Mattress 3 laid out with its longer side towards the finish line – the distance from the beginning to the nearer edge of the mattress equals 15.5m
- The gym bench placed along the finish line – the distance from the beginning to the nearer side of the bench equals 18.5 m
- Mattress 4 laid out with its longer side towards the finish line V the distance from the beginning to the nearer edge of the mattress equals 22m
- Two medicine balls next to each other at a distance of 3 m – from the beginning to the line joining the balls: 25 m
- The weights of 17.5 kg and the first stand – the distance from the beginning: 26 m

Endurance training – *noun* exercises designed to increase an athlete's level of aerobic fitness [38].

Fast twitch fibre – *noun* a type of muscle fibre that contains high levels of ATP and is able to contract swiftly [38].

Slow twitch fibre, slow fibre – ***noun*** a type of muscle fibre that is not able to contract swiftly [38].

Electromyography – it is an experimental technique concerned with the development, recording and analysis of myoelectric signals. Myoelectric signals are formed by physiological variations in the state of muscle fibre membranes.

EFPA – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [39, p. 19].

- Stand two - distance from the beginning: 30m
- 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: 32.5m
- The third hurdle 63 cm in height – distance from the beginning: 33.5m
- The fourth hurdle 75 cm in height – distance from the beginning: 37.5m
- The fifth hurdle 75 cm in height – distance from the beginning: 39m
- The sixth hurdle 75 cm in height – distance from the beginning: 41.5m
- The springboard approximately 0.5 m in front of the box
- Box V distance from the beginning: 50m
- Mattress 5 laid out with its longer side towards the finish line – the distance from the beginning to the nearer edge of the mattress equals 52.70m
- Mattress 6 laid out with its longer side towards the finish line – the distance from the beginning to the nearer edge of the mattress equals 54.70m
- Finish line – the distance from the beginning of the track (the starting line): 60 m

Description of performing ASET

The examined person stands on the starting line and on the command "Ready" enters stand 1, taking the position "plank – both feet in the internal circle, the torso in the direction of the axis of the track". On the start signal – the time is measured. The diagram of executing the fitness 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 approximately 360 degrees; the feet do not exceed the internal circle.

Stand 2 – placing the left hand in the middle of the circle and moving in the supported position 360 degrees in the anti-clockwise direction.

Stand 3 – placing the right hand in the middle of the circle and moving in the supported position 360 degrees in the clockwise direction.

Stand 4 – lying perpendicularly on the edge of the mattress, arms held straight above the head, rolling the torso to the right.

Stand 5 – lying perpendicularly on the edge of the mattress , arms held straight above the head, rolling the torso to the left.

Stand 6 – Sitting on the edge of the bench with hands placed on the neck, moving the body using feet towards the other end of the bench.

Stand 7 – forward roll on the mattress.

Stand 8 – running on the reversed side of the bench.

Stand 9 – backward roll on the mattress.

Stand 10 – changing the position of 3 kg medicine balls arranged at a distance of 3 m from each other, perpendicularly to the track axis.

Stand 11– running with two weights of 17.5 kg around stands which are set up along the axis of the track at a distance of 4 m and placing the weights on the previously marked spot.

Stand 12 – jumping over three 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 to the four part vaulting box, then doing a forward roll on the box.

Stand 15 – running "on all fours" towards the finish line.

Stand 16 – handstand at the wall at the finish line – stopping the timer.

Statistical analysis

The results of the investigation were analysed statistically by calculating the average values (mean), standard deviation (SD or ±) for age, height and body weight of individual endurance tests such as: 40/100/1000/2000m run, pull-ups and ASET in

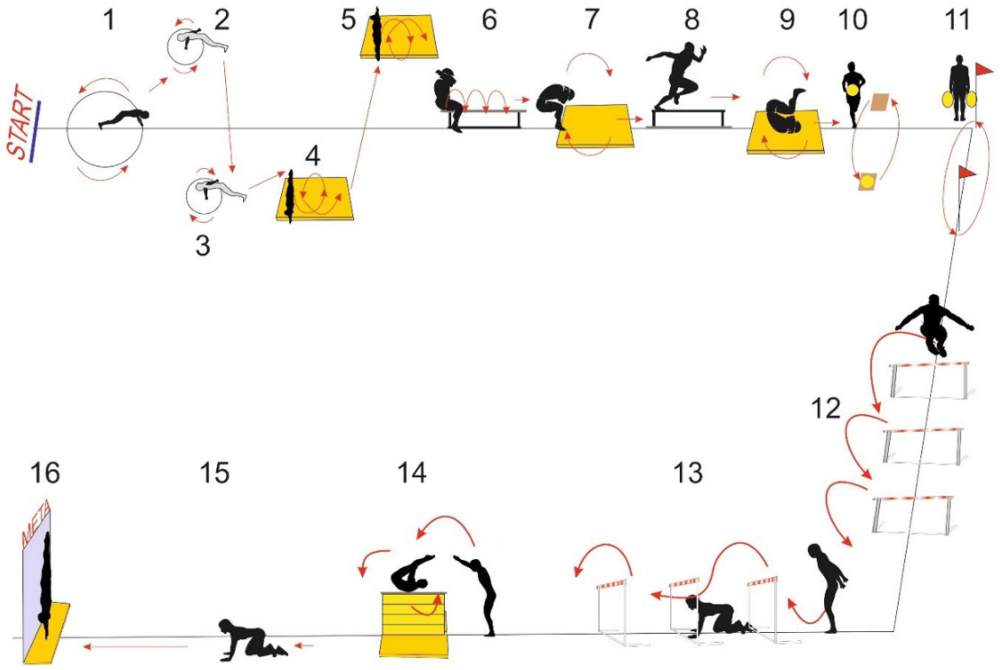

Figure 1. ASET diagram [2].

the examined groups. A normal distribution of all the examined variables was checked by means of the Kolmogorov-Smirnov test. The authors calculated the difference in the investigated indicators among the examined groups, using an analysis of variance (ANOVA). Calculations of r-Pearson correlations were made in the test groups, between ASET and efficiency tests. All statistical analyses were performed using the IBM SPSS 9 statistical software package. The values of the calculations were considered statistically significant when the p-value was under 0.05.

The analysis of the correlation results: 1) a sprinter race with the endurance race; 2) strength with endurance; 3) speed with strength; was conducted by constructing a table, using the X and Y coordinates. These two components enabled each individual result to be put in the proper "square" of the figure. Each square indicates the motor type of the testes cadet

RESULTS

The results of the body weight, body height and BMI show statistically significant differences at $p<0.000001$, $p<0.0005$ and $p<0.000001$ between group A and B. It was observed that the results of the body weight, body height and BMI are statistically lower in group A with $p<0.0005$, $p<0.05$ and $p<0.005$ in relation to all the examined persons ($n = 59$). The results of the same variables are statistically significantly higher in group B with $p<0.0005$, $p<0.05$ and $p<0.005$ respectively in relation to all the examined persons. The results obtained in running tests for 40 m, 2000 m, 100 m, 1000 m, in pull-ups and in ASET did not show a statistically significant difference between the examined groups (Table 1).

In the individual results of cadets with a predisposition for a sprinter race showed a negative correlation with the results of the endurance race in fifteen cadets, including three cadets above + 1s and one above + 2 s. On the other hand, fourteen cadets with a predisposition for a sprinter race showed a negative correlation with the results of a sprinter race, including three cadets above + 1s, two above + 2 s and one above +3 s. Thirteen cadets had a predisposition for a sprinter race and an endurance race, including four cadets for a sprinter race above +1 s and one above +3 s. Seventeen cadets had no talent for a sprinter and endurance race. In group A there were five cadets who demonstrated a predisposition for a sprinter race and ten in group B.

Eight persons among the examined ones in the test group A showed a predisposition for an endurance race and six from group B. Eight examined persons had a talent for a sprinter race and an endurance test in group A and five from group B. No talent was demonstrated in a sprinter race and an endurance race in nine examined persons of test group A and eight from group B (Figure 2).

Table 1. Somatic data and the results of physical fitness of the examined groups (mean and SD).

Variable	All (n = 59)	Group A (n = 30)	Group B (n = 29)
Age (years)	20.06 ±2.25	19.13 ±1.07	20.62 ±2.95
Body weight (kg)	73.86 ±7.61	68.10 ±4.05***	79.82 ±5.53***§
Body height (cm)	179.10 ±5.74	174.70 ±5.09*	181.68 ±5.27*†
BMI *(kg · s –2)*	23.00 ±1.73	21.85 ±1.28**	24.18 ±1.29***§
40m run *(m · s –1)*	6.96 ±0.45	6.94 ±0.46	6.98 ±0.44
2000 m run *(m · s –1)*	4.01 ±0.31	4.05 ±0.31	3.97 ±0.32
Pull-ups (number)	13.35 ±3.36	14.06 ±3.07	12.62 ±3.54
100 m run *(m · s –1)*	7.49 ±0.33	7.49 ±0.37	7.49 ±0.29
1000 m run *(m · s –1)*	5.03 ±0.24	5.07 ±0.30	4.99 ±0.17
ASET	1.37 ±0.13	1.36 ±0.13	1.37 ±0.12

* difference statistically significant relation to all examined persons with p<0.05; ** difference statistically significant relation to all examined persons with p<0.005; *** difference statistically significant relation to all examined persons with p<0.0005; † difference statistically significant relation to group A at p<0.0005; § difference statistically significant relation to group A at p<0.000001.

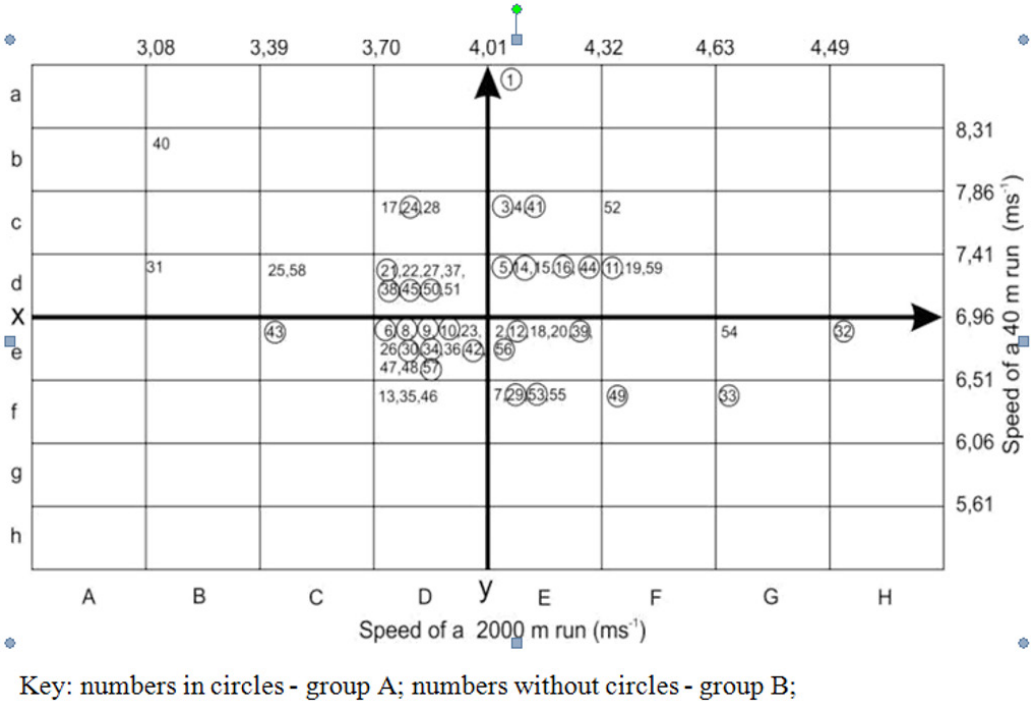

Figure 2. The results obtained in the speed and endurance test.

Among all the examined cadets, the highest speeds of executing ASET was demonstrated by the endurance-speed type (En-Sp), reaching an average speed V = 1.40 m/s. In group A, En-Sp achieved the highest average speed of 1.42m/s in the execution of ASET. In group B, the highest average speed V = −1.40 m/s was obtained by the endurance type (En). There were no statistically significant differences in the speed of ASET execution between these motor types (Table 2).

The conducted efficiency tests prove that the cadets had different predispositions for this kind of a physical effort.

The X axis in Figure 2 was the average speed of 59 examined cadets during a race over 40 m (6.96 m/s ±0.45). The upper half of the figure contained the results over one SD (+1s) (6.96 + 1 × 0.45 = 7.41), by 2 SD (+2s) (6.96 + 2 × 0.45 = 7.86) and by 3 SD (+3s) (6.96 + 3 × 0.45 = 8.31). The bottom half of the figure contained the results lower than the mean value, decreased by one SD (−1s) (6.96 − 1 × 0.45 = 6.51), by 2 SD (−2s) (6.96 − 2 × 0.45 = 6.06) and by 3 SD (− 3s) (6.96 − 3 × 0.45 = 5.61). The Y-axis ran vertically across Figure 2 and constituted the mean of the results of 59 cadets in the race over a distance of 2000 m (4.01 m/s ±0.31) by dividing it into the left and right side. The right half of the table contained the results higher than a mean value over one SD (+s) (4.01 + 1 × 0.31 = 4.32), by 2 SD (+2s) (4.01 + 2 × 0.31 = 4.63) and by 3 SD (+3s) (4.01 + 3 × 0.31 = 4.94). The left half of the figure contained the results lower than the mean value, decreased by one SD (−1s) (4.01 1 × 0.31 = 3.70), by 2 SD (-2s) (4.01 − 2 ×·0.31 = 3.39) and by 3 SD (-3s) (4.01 − 3 × 0.31 = 6).

Individual results of seven examined persons with predisposition for an endurance race showed a negative correlation with the results of strength attempts, including two with endurance predisposition above +1 s. In fourteen patients with a predisposition for strength, there was a negative correlation to the results of the endurance race. Twenty cadets showed a predisposition for endurance and strength, including the endurance race; four were above +1s, two above +2s and one above +3s, whereas for strength three were above +2s and one above +2s. Eighteen cadets showed no predisposition for endurance and strength In group A, two cadets had a predisposition for an endurance race; similarly five cadets in group B. Seven examined cadets in group A demonstrated a predisposition for strength, as was the case of seven examined persons in group B. In Group A in fourteen cadets the authors observed a predisposition for endurance and strength; likewise, six cadets in group B. Seven cadets in group A showed no predisposition for endurance and strength; similarly eleven cadets from group B (Figure 3).

Among all the examined ones with a predisposition for endurance and strength, the highest speed of executing ASET was demonstrated by the endurance-strength type (En-St), reaching an average speed V = 1.42m/s. It was found in the group of all the examined participants, at $p<0.02$, a statistically significant higher speed of performing ASET in En-St compared to the endurance-strength motor type, with low efficiency (En-StL). Low efficiency is determined by below average results placed on the X and Y axis in Figure 3. Group B was found to demonstrate a higher speed of performing ASET in En-St, compared with the endurance motor type (En) and En-StL, respectively at $p<0.01$ and $p<0.05$. In group B,

Table 2. Speed (mean and SD) achieved during the ASET execution by all the examined cadets (n = 59), in group A (n = 30) and in group B (n = 29) with a predisposition for endurance and speed.

Subject	En-Sp speed $(m \cdot s^{-1})$	Sp speed $(m \cdot s^{-1})$	En speed $(m \cdot s^{-1})$	En-SpL speed $(m \cdot s^{-1})$
All	1.40 ±0.11 (13)	1.33 ±0.16 (15)	1.39 ±0.10 (14)	1.35 ±0.12 (17)
Group A	1.42 ±0.13 (8)	1.28 ±0.11 (5)	1.39 ±0.11 (8)	1.34 ±0.14 (9)
Group B	1.38 ±0.09 (5)	1.33 ±0.21 (10)	1.40 ±0.08 (6)	1.37 ±0.09 (8)

En-Sp endurance-speed motor type; **Sp** speed motor type; **En** endurance motor type; **En-SpL** endurance-speed motor type with low efficiency (lack of predisposition); **()** number of examined persons.

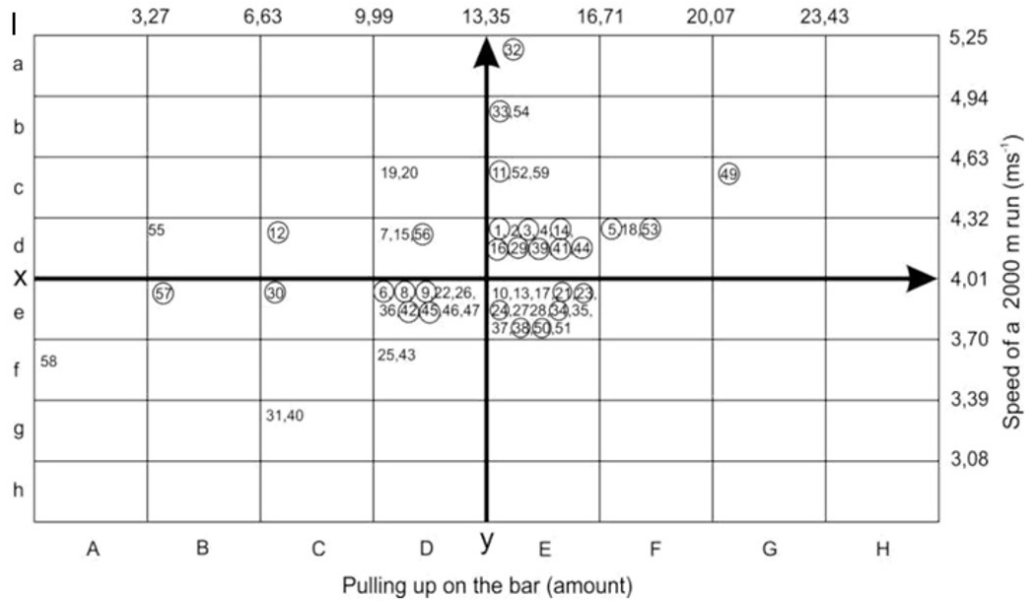

Figure 3. The results obtained in the speed and endurance test.

the strength motor type demonstrated a higher speed of performing ASET in relation to En at $p<0.05$ (Table 3).

The individual results of fourteen persons with a predisposition for strength demonstrates a negative correlation with the results of a sprinter race, including two with a predisposition for strength above +1s and one above +2 s. Seven examined persons with a predisposition for a sprinter race exerted a negative correlation of the results of strength, including one with a predisposition for a sprinter race above +2 s. Twenty-one examined cadets showed a predisposition for a sprinter race and strength, including one with a predisposition for strength above +1s; seven for a sprinter race above +1s and one above +3s. In seventeen examined persons there was no predisposition for a sprinter race and strength. In group A there were eight cadets with a predisposition for strength and five cadets in group B. In group B, seven examined persons had a predisposition for a sprinter race. In group A thirteen persons had a predisposition for a sprinter race and

Table 3. Speed (mean and SD) achieved during the ASET execution by all the examined cadets (n = 59), in group A (n = 30) and group B (n = 29) with a predisposition for endurance and strength.

Subject	En-St speed $(m \cdot s^{-1})$	St speed $(m \cdot s^{-1})$	En speed $(m \cdot s^{-1})$	En-StL speed $(m \cdot s^{-1})$
All	1.42 ±0.10 (20)	1.37 ±0.08 (14)	1.37 ±0.12 (7)	1.32 ±0.15** (18)
Group A	1.39 ±0.12 (14)	1.29 ±0.09 (7)	1.46 ±0.10 (2)	1.35 ±0.16 (7)
Group B	1.44 ±0.07 (6)	1.44 ±0.09 (7)	1.33 ±0.05***† (5)	1.29 ±0.15* (11)

En-St endurance-strength motor type; **St** strength motor type; **En** endurance motor type; **En-StL** endurance-strength motor type with low efficiency (lack of predisposition); ***the difference statistically significant in relation to the En-St at $p<0.01$; **the difference statistically significant in relation to the En-St at $p<0.02$; *the difference statistically significant in relation to the En-St at $p<0.05$; **†** the difference statistically significant in relation to the St at $p<0.05$; **()** number of examined persons.

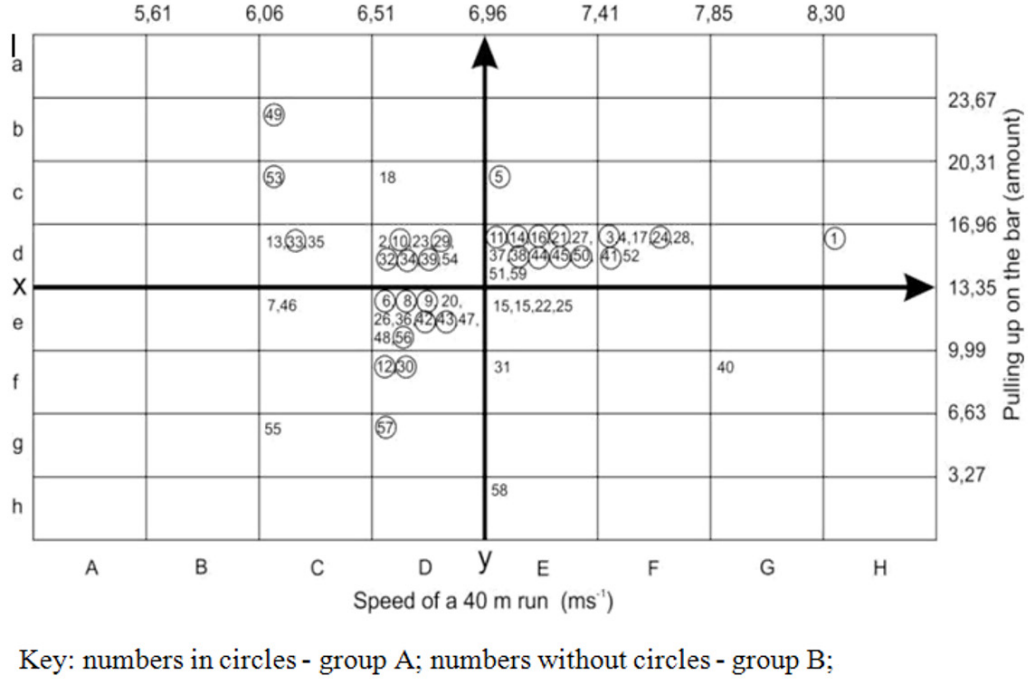

Figure 4. The results obtained in the speed and endurance test.

strength; similarly it was the case of eight persons in group B. Nine persons in group A showed no predisposition for a sprinter race and strength; similarly eight persons from group B (Figure 4).

Among all the examined ones with a predisposition for speed and strength, the highest speed of executing ASET was demonstrated by the speed-strength type (Sp-St), reaching an average speed V = 1.40 m/s. In group A, Sp-St achieved the highest average speed of ASET execution equal to V =1.37m/s. In group B, Sp-St achieved the highest average speed of ASET execution equal to V =1.45 m/s. Sp-St showed a statistically significant higher speed in performing ASET in comparison with the speed motor type (Sp) and speed- strength motor type, with low efficiency (Sp-StL), respectively at $p<0.05$ and $p<0.05$ (Table 4).

In the group of all the participants (n = 59) the authors found a statistically significant correlation between ASET and pull-ups, ASET and race for 100 m, and ASET and race for 1000 m at the level of significance with $p<0.05$, $p<0.05$ and $p<0.005$, respectively. In group A, the statistically significant correlation between ASET and a race

Table 4. Speed (mean and SD) achieved during the ASET execution by all the examined cadets (n = 59), in group A (n = 30) and group B (n = 29) with a predisposition for speed and strength.

Subject	Sp-St speed $(m \cdot s^{-1})$	St speed $(m \cdot s^{-1})$	Sp speed $(m \cdot s^{-1})$	Sp-StL speed $(m \cdot s^{-1})$
All	1.40 ±0.12 (21)	1.38 ±0.11 (14)	1.26 ±0.17 (7)	1.36 ±0.12 (17)
Group A	1.37 ±0.13 (13)	1.35 ±0.10 (8)	0	1.37 ±0.15 (9)
Group B	1.45 ±0.07 (8)	1.43 ±0.10 (6)	1.26 ±0.17* (7)	1.35 ±0.06 (8)

Sp-St speed-strength motor type; **St** strength motor type; **Sp** speed motor type; **Sp-StL** speed-strength motor type with low efficiency (lack of predisposition); *the difference statistically significant in relations to the Sp-St at $p<0.02$; **( )** number of examined persons.

over 1000m with the level of significance p<0.05. In group B, are statistically significant correlation between the ASET pull-ups, race over 1000 m on the level of significance equal to p<0.005 and p<0.002, respectively (Table 5).

The analysis of the findings showed that eleven pilot cadets from the examined population, marked with numbers 1, 3, 4, 5, 11, 14, 16, 41, 44, 52, 59 had the following motor skills: endurance-speed, endurance-strength and speed-strength (Figure 2, 3, 4).

DISCUSSION

The investigations demonstrated that the average body weight, body height and BMI were statistically significantly different among the examined groups, which had an impact on determining motor predispositions. There was no statistically significant difference among the examined groups in the endurance tests (Table 1). The applied method of the analysis of endurance results demonstrated that in the examined groups, it was possible to select cadets with the following motor skills: endurance-strength type (En-St), endurance-speed type (En-Sp), speed-strength type (Sp-St), speed type (Sp), strength type (St) as well as endurance type (En).

In these investigations it was observed that the examined persons who had only one dominant motor skill was had poorer results in ASET execution than those with double motor skills, e.g. endurance-strength (Figure 3). Better results were found in cadets with single skills rather than in those with double skills in only two cases (Table 3). It is worth noting that in eleven cadet pilots, the authors found double motor skills of three motor types: En-Sp, En-St, Sp-St. Presumably, this is the effect of genetic predispositions along with an excellent physical preparation for their entrance examinations to the academy. However, the examined persons who demonstrated double skills in En-St and were placed in squares fA, eB, eC, eD fD, gC in Figure 3, showed low physical capacity and a lack of a predisposition in a given motor skill. Likewise, lack of predispositions was found in En-Sp and Sp-St.

Opinions about the motor types of candidates who proved suitable for service in the Air Force were not uniform. There were opinions by Oksa et al. [4] and Chen et al. [3] and that the most important skills in a pilot are strength and speed. On the other hand, endurance plays the least important role since endurance training increases the sensitivity of a human body to the G-strain stimulus in the +Gz axis (head-feet direction) [13]. Moreover, cases of a decline in tolerance were observed in a study by Whinnery and Parnell [13]. The main cause of the diminished tolerance was an improperly conducted training of aerobic endurance (intensity and load) combined with strength training [14].The opinion that endurance plays a smaller role than other motor skills of pilots seems unfounded. It needs to be emphasized that endurance is a crucial motor skill of the pilot taking into account the time necessary to execute manoeuvre L-1 and the number of its repetitions. Shaping both endurance and strength in the pilot requires precise training as well as a selection of motor skills in candidates for military aviation. Recent research conducted in a centrifuge proved that the longest total

Table 5. Indicators of correlation and evaluation of statistical significance between the results of individual fitness tests and results of ASET in the examined groups.

Variable	r- Pearson's correlation ASET *(m · s –1)*		
	All (n = 59)	Group A (n = 30)	Group B (n = 29)
Speed of 40 m run *(m · s –1)*	0.09	0.12	0.06
Speed of 2000 m run *(m · s –1)*	0.14	0.04	0.26
Pull-ups (amount)	0.26*	–0.03	0.56**
Speed of 100 m run *(m · s –1)*	0.26*	0.23	0.31
Speed of 1000 m run *(m · s –1)*	0.41**	0.38*	0.54***

*p<0.05; **0.005; ***p<0.002.

spinning time, of interval characteristics, was achieved by cadets with endurance-strength skills, and the weaker results were reached by a group of speed-strength skills [12]. The investigation was additionally monitored by a lipid indicator, which confirmed this fact.

Taking into account the previously mentioned groups of skeletal muscles involved in the anti-strain manoeuvre L-1 during the test on a centrifuge and also during ASET execution, this investigation confirms that the endurance-strength type is suitable for the Air Force service. Among all the examined cadets, En-St reached the highest average speed of ASET execution in relation to En-Sp and Sp-St (Table 3). In group B, En-Sp achieved better average speed results of ASET execution compared to En-St and Sp-St. In group B, Sp-St achieved a better average speed of ASET execution than it was the case of En-St and En-Sp. This fact proved that the motor skills of the examined persons, taking into account body weight in groups A and B, exert an effect on speed in ASET execution. In group B, the authors observed that En-St and St obtained a higher average speed of ASET execution compared to group A and all the examined cadets, with a statistically significant difference between group A and B with regard to height and body mass.

Referring to the statistically significant correlation occurring in a group of all examined persons, between ASET and pull-ups, 100m and 1000m distance, it must be emphasized that ASET was properly constructed with regard to the pilot's motor adjustment to extreme environmental conditions of the profession. It is important for preparing pilots to fly combat missions. A significant correlation between ASET and endurance tests was confirmed by the authors' own earlier research.[1] In this study there is a significant correlation occurring in group A, due to ASET and the distance of 1000 m, and in group B ASET and pull-ups and the distance of 1000m prove that somatic qualities play an important role when determining the types of motor skills as well as in the assessment of physical fitness. Therefore, specifying motor types, including somatic qualities is a prerequisite for the selection of candidates for service in military aviation. Body build determines motor skills [15, 16]. In previous studies, between the examined groups it was possible to observe a statistically significant difference in body height. No such difference was found with regard to body weight and endurance tests: pull-ups, 100m and 1000m. The studies by Wochyński et al. [1] indicated that the group of the lowest average body height (177.03 cm), achieved the best result in ASET execution.

These studies prove that there was a significant difference in body weight and body height among the examined groups, however, no statistically significant difference was observed in endurance tests, such as pull-ups, 100m, 1000m and ASET. On the basis of a thorough analysis of endurance tests, it appears that the cadets who have reached their maximum results during the endurance tests did not have good results in executing ASET. This fact can be attributed to exceeding workload during endurance tests, in general physical condition, which may have a direct relationship with a reduction in the level of motor skills, necessary for the pilot.

The relationship of the workload with a decrease in motor co-ordination was observed in another study [11]. It seems that it depends on somatic qualities, and in this case it may depend not only on body height but also on body weight, which may have an impact on the level of neurosensory predispositions. In the group of all the examined persons, the average body height was similar to the body height in previous study by Wochyński et al. [1] and was equal to 179.01 cm. In this group, En-St achieved the best results in the execution of ASET (Table 3). The investigations conducted by Ziółkowska [17] proved that long limbs, torso and body height are selective factors for the pilot's job. Our research has shown that body weight influences motor skills. The evidence is a significant correlation between the results achieved in ASET and the results in pull-ups in Group B (over 73.8 kg). In Group A (below 73.8 kg) no significant correlation was observed.

The conducted investigation proved that specifying the motor types for military aviation is necessary due to performing tasks in the extreme conditions of the pilot's job as well as safety. It was found that somatic qualities are a factor determining an appropriate motor skill. This is proved by somatic qualities of the examined persons in Group A and B. Although they varied, motor endurance-speed skills (Group A) and endurance-strength skills (Group B) were observed, achieving the highest speed of ASET execution. Proving a statistically significant

difference in the speed of ASET execution, among the examined types of motor skills, points to a high diagnostic value of this test for the selection of aviation candidates. The presented results of the investigations may also have an influence on the distribution of training components in the physical preparation of the pilot.

This issue is important because the preparation of a modern military pilot requires an optimal combination of two types of adaptation: tolerating unfavourable working conditions in the air; ability to survive in situations of forced landing in the territory occupied by the enemy [19, 20]. Therefore, future research should include the correlation of ASET's results with the results of motor and psychomotor simulations specific to survival competences [21-28]. This conclusion is justified, inter alia, by the results of the latest research by Tomczak and Bąk [29] providing empirical argumentation that despite many recommendations based on theoretical and empirical research on Polish military pilots [7, 14, 20, 12, 28], there is no radical progress. Innovative revision of training programs should take into account, inter alia, various forms of extreme physical activity (EFPA) in combination with fun forms of martial arts (which are much safer than training in combat sports based on sports formulas) [30-35], and are accepted by adolescents and adults and bring many benefits also concerning mental health [36, 37].

CONCLUSIONS

The speed in ASET execution by the examined persons is closely related to their motor skills (predispositions), which undoubtedly exerts a tremendous practical role in the selection of pilots for military aviation. The investigation demonstrated that in the group of all examined cadets, En-St reached the highest average speed in the execution of ASET, which confirms the usefulness of this test for the selection of future military pilots. In group A the highest speed in ASET execution was achieved by the endurance-speed type, whereas in group B it was achieved by the speed-strength type, which indicates that somatic qualities may be closely related to motor skills.

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