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Psychomotor performance of Polish Air Force cadets after 36 hours of survival training

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Abstract

Introduction. The preparation of Polish Air Force cadets for survival in isolation is a necessary element of their training, to demonstrate just how difficult can be the conditions they could encounter in a combat situation.
Objective. The aim of the research was to assess the effect of long-term survival training on selected coordination motor skills in Air Force cadets.
Materials and method. Fifteen air force cadets aged 19.6±0.3 years exercised for 36 hours during survival training without the possibility to sleep. They were examined 4 times: Day 1 – before effort (training), Day 2 – after 24 hours training, Day 3 – directly after 36 hours training, Day 4 – next day, after an all night rest. They were examined for shooting and reaction time, the ability to maintain body balance, running motor adjustment, handgrip force differentiation, and on Days 1 and 3, exercise capacity was evaluated with a 1 mile walking test.
Results. The survival training resulted in significant decreases in maximum handgrip strength, corrected 50% max handgrip, maintenance of body balance and heart rate. No changes occurred in reaction time, running motor adjustment and shooting performance. Overnight rest did not result in recovery of any of the examined factors to the values observed on Day 1.
Conclusion. Survival training combined with sleep deprivation mostly affected peripheral factors depending on strong action from both muscles and nervous system, whereas complex tasks involving short-term central alertness and moderate exertion were maintained. In order to improve performance, more endurance strength training, if possible combined with sleep deprivation, should be introduced in military training.

Key words
military training, survival, sleep deprivation, coordination motor skills

INTRODUCTION

For many years, Polish soldiers have been participating in major military missions led by NATO. The missions are dangerous, held in harsh climatic and geographical conditions. During the missions in certain circumstances, each soldier may find himself isolated from his own troops. Soldiers are prepared for such events in survival courses and Survival, Evasion, Resistance, Escape (SERE). Trainings for military pilots have been conducted for several years at the Military Training Centre which last about one week and end with a one-and-a-half day continuous, practical field exercises. For the aviation cadets, during military basic training, there occasionally take place survival school classes lasting several dozen hours. During these courses, the cadets have the opportunity to learn how to survive in diffficult situations in isolation, and can assess their psychological and physical capabilities. For scientists, such training is a good opportunity to carry out research on the effects of psychomotor performance of soldiers during military training. These data can be used for modeling training programmes to prepare the troops for survival in conditions of complete isolation [1].

In the literature, there are many articles containing the results of studies carried out during various types of long-term military training. Most commonly, the researchers have focused on changes occurring from the psychological aspects [2–6]. Less explored in survival literature are studies focused on changes in coordinations motor skills and physical fitness during survival training [7–11].

Koulman et al. (2011) examined cognitive aspects, that mood state, short- and long-term memory and reaction time were not altered by 5 days in field survival conditions (moderate activity). Similarly, in the 36-hour survival training, characterized by moderate physical effort, no deterioration was found in visual coordination [9] and multiple choice reaction time (MCRT) [8].

The effect of 36 hours of moderate physical activity combined with sleep deprivation on body balance disturbation tolerance skills (BBDTS) was determined using the rotation test [8, 11]. In the presented study, there was deterioration of BBDTS duration the survival training. Also, in similar training conditions, tests conducted by posturograph demonstrated a worsening of static equilibrium [7]. The influence of the weight of military equipment and fatigue on postural stability were examined many times [12–14]. It was found that the weight of the military equipment and fatigue caused deterioration in balance, which correlated with the number of resulting injuries of the lower limbs.

Divergent results were obtained in previous studies on hand muscle strength (hand grip) and the ability of its differentiation during prolonged physical activity associated with military training. Civilians trained in summer had increased hand muscle strength [8], while during winter training there were no statistically significant differences. Special unit soldiers did not reveal differences in the strength of hand muscles during 72 hours of training [15]. Riikonen

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et al. (2011) observed a decrease in hand muscle power after 8 days of military field training. Hand muscle strength differentiation capacity deteriorated during the winter training of civilians.

Motor adjustment factors during military training have also been examined. During the winter survival training of survival instructor candidates, a reduction of sprinting speed of 15 m and improvement of speed on 3×5 m and 15 m slalom was observed.

The results of shooting efficiency appear very rarely in scientific studies relating to military training. Tomczak and Kalina (2007) found that as a result of disturbances of homeostasis caused by running for a distance of 800 m, better results were obtained by police from the anti-terrorist unit than cadets from the land and air forces.

The significant role of coordination motor skills in military training is generally acknowledged because nowadays soldiers have to handle more complicated equipment and means of warfare. For this reason, the aim of the presented research was to assess the effect of long-term survival training on selected coordination motor skills in Air Force cadets.

MATERIALS AND METHOD

Participants. Fifteen Air Force cadets, future high performance aircraft (HPA) pilots, after signing informed consent, took part in a 36-hours continuous survival training course. They had just started military education at the Polish Air Force Academy in Deblin, eastern Poland, after completing the physical performance tests and advanced aviation medical examination. The average age of the subjects was 19.6±0.3 (SE) years; average height – 178.7±1.7 cm, body weight – 72.0±2.1 kg and BMI 22.5±0.4 kg/m^2. The training took place on a plain in summer (ambient temperature ranging from 22 °C to 14 °C at night). The study protocol was approved by the Ethics Committee of Medical University in Warsaw (Permission No. KB/213/2010).

Training programme. During 36 hours of continuous training, the subjects were completely deprived of sleep. The training programme included basic combat skills, drill after combat alarm, camouflaged regrouping, reconnaissance making, observation, acting as a patrol member, operation in contaminated areas, transport of wounded soldiers, shelter preparation and a military obstacle run. Total distance covered – 30 km.

Throughout the entire training, the Air Force cadets carried a rucksack with basic soldier's equipment and a firearm; total weight – 10–12 kg.

Test methods. The following tests were performed to measure selected psychomotor factors:
1. strength of forearm muscles and ability of its differentiation;
2. running motor adjustment (running tests);
3. reaction time;
4. rotational test [17];
5. exercise capacity;
6. shooting performance.

Description of tests

Strength of forearm muscles and ability of its differentiation – with the use of MDAa 10/II dynamometer held in the preferred hand, standing posture, arms along the trunk: maximum strength, an attempt at applying 50% of the maximum strength, and then an attempt at adjusting the force to attain the requested 50%. Every variant was repeated 5 times and the respective averages were then computed. The results were presented as maximum force (in N) and differences between the 50%-test result and half the actual maximum force. The differences were presented as actual and absolute, to reflect the mean effect and the total error.

Motor adjustment (running tests): 15 m straight sprint (SS), shuttle run 3×5 m (SR; standing start), 15 m slalom run (SL; first pole at a 5 m distance from the start, the other 4 spaced at 1.2 m; standing start), 15-m squat (SQ), crouching start. Running times were recorded electronically with 0.01 s accuracy. Results were presented as velocities (15/time) and as standardized values.

Reaction time. Evaluated by measurement of reaction time at a given pace using an APK 2/04 device (UNI PAR, Poland). Two tests were used:
1) *Piorkowski test.* Subjects were supposed to react as fast as possible by pressing one of the 10 buttons, each one corresponding to one of 10 related lights. The APK device was placed on a table with appropriate height to provide comfortable operation in a standing position using both hands. The pace of stimulus display was set to 107 impulses per minute. The following indicators were recorded: correct response, abandoned reactions, and incorrect response.
2) *Cross test.* A cross-reaction device consisting of a keyboard containing 2 perpendicular rows of 7 lights each. Response buttons are arranged in rows corresponding to all lights in a 7×7 pattern (total 49). Subjects performed the test facing the desktop, and by pressing the response buttons with the index finger of the dominant hand. The task was to press the button at the intersection of 2 lights lit in each row at a rate of 49 per minute. The following indicators were recorded: the number of stimuli received and the number of errors.

Rotational test as measurement tool of the body balance disturbation tolerance skills. Assessed with a rotation test: starting standing on the line subjects were supposed to spin 360° in the air (alternately 3 times clockwise and 3 times counter-clockwise) and land with both feet on the line in approx. 12 sec in a constant rhythm. Several training jumps were allowed. The accuracy of landing and maintaining balance was scored: 0 – clean jump, 1 – one foot off the line, 2 – both feet off the line, 3 – lost balance with hand support, and summarised from 6 jumps (score range from 0 – excellent, to 18 – unsatisfactory).

Exercise capacity. A walking test was performed on a track at the distance of 1600 m (1 mile). Subjects were warmed-up and instructed to cover the distance as fast as possible but without running and at least one foot always in contact with the ground. Time and heart rate were recorded at the finish line. Maximal oxygen uptake was evaluated using data obtained before prolonged exercise and sleep deprivation according to the formula described by Kline et al. (1987) [18]: VO_2max = 132.853 – (0.0769 × body mass in lbs) – (0.3877 × age in years) + (6.315 × gender [male 1, female 0]) – (3.2649 × time in minutes and seconds calculated as hundreds of a minute) – (0.1565 × heart rate in beats per minute).

Shooting with an air gun (Zoraki HP-01, 4.5 mm, maximal initial speed 190 m/s) was performed in a standing position from the distance of 5 m at a 14 cm target, and 1 – 10 scoring. Several familiarizing shots were allowed before recording 5 shots to be summed up for the final result.

Data analysis. All data presented as means ±SE. Kolmogorow-Smirnow's test was used to check the normality of distributions.

The between-day differences in mean values were assessed using Student`s test for dependent measures. Statistica 6.0 software was used in data analysis with the level of significance set at $p<0.05$.

RESULTS

One sleepless night combined with prolonged exercise of moderate intensity resulted in a decrease in forearm muscle strength, and deterioration of forearm muscle strength differentiation ability (requested attempts of 50% of maximum hand grip) (Tab. 1; Fig. 1).

There were no significant changes in reaction time in the Piorkowski and Cross tests. The only significant difference was found in the number of mistakes made between Day 1 and Day 4 (Tab. 1).

Significant differences were found in the rotation test results. The results deteriorated steadily (Fig. 1).

Table 1. Average (±SE) values recorded in performed tests (forearm muscle strength differentiation, running motor adjustment, reaction time and shooting)

Value	Day 1	Day 2	Day 3	Day 4
Forearm muscle strength differentiation [N]				
50% max	396±89	359±316	380±95	353±72
Corrected 50% max	355±80	316±85*	322±82*	314±71*
Error 50%	17±58	2±39	30±39	14±25
Error corr.	-23±40	-41±32*	-28±22	25±30
Running motor adjustment test [m/s]				
15 m	4.84±0.2	4.73±0.2*	4.71±0.3*	4.63±0.2*
3 x 5m	2.79±0.1	2.80±0.3	2.86±0.2	2.80±0.1
15 m slalom	2.93±0.2	2.93±0.2	3.00±0.2	2.93±0.2
15 m squat	3.21±0.4	3.07±0.4	3.19±0.4	3.11±0.4
Psychomotor performance – Piórkowski test				
Correct responses	77.2±9.5	77.4±9.5	80.5±9.8	78.9±8.0
Abandoned reactions	16.7±6.8	16.2±7.5	15.2±8.6	17.8±7.2
Incorrect reactions	13.1±6.2	13.4±5.1	11.3±9.3	10.3±3.7*
Psychomotor performance – Cross test				
Cross reaction	44.4±4.9	42.7±4.1*	39.7±3.4*	39.7±3.6*
Cross reaction errors	1.8±1.7	2.1±2.1	1.4±1.8	1.8±1.9
Shooting [points]				
Result	35.5±7	36.2±7	36.0±6	38.1±5

* – p<0.05 between Day 1 and Days 2, 3 and 4.

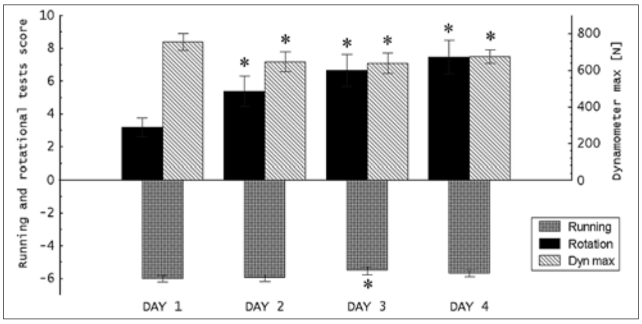

Figure 1. Values of maximal forearm muscle strength (Dyn max), rotational (Rotation) and running motor adjustment (Running) tests scores during 4 days of testing.
* – p<0.05.

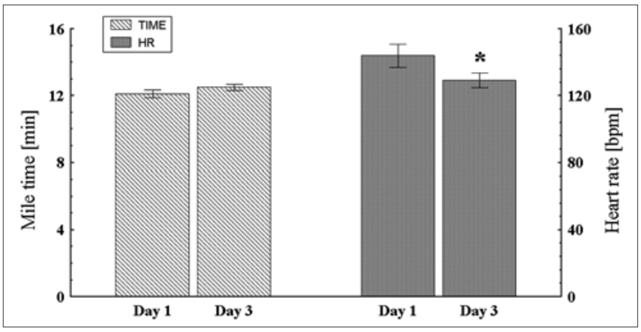

Figure 2. Heart rate and time at the end of 1 mile walking test performed on Days 1 and 3.
* – p<0.05.

Heart rate at the end of the walking test was significantly lower in the trial after prolonged exercise and sleep deprivation than at the entry measurements (132±3 bpm vs. 148±6 bpm $p<0.01$). Walking time was similar in both trials (12.1±0.2 min vs 12.5±0.2 min) (Fig. 2).

No significant differences found in shooting (Tab. 1).

An overnight rest of 7–8 hours did not influence forearm muscles strength, force differentiation, dynamic balance and running motor adjustment.

DISCUSSION

In both sports and military literature, there are few data concerning coordination motor skills connected with survival schools. The experiment involving Air Force cadets and testing protocols applied in this study is exceptional and the first to be carried out in the Polish Armed Forces. Such studies are important for national defense, as proper physical training can improve the execution of precise tasks during military action in isolation, e.g. psychological training reduces stress in combat situations. Although there is a commonly applied solution of using pharmacological stimulants during prolonged military action [19–21], better and healthier results can be achieved by proper physical training. Drugs work for a certain period of time, have side-effects and are not always available. Air Force cadets are a group of men selected according to their exceptional health status and psychophysical predispositions for further education as pilots of military aircraft.

The tests conducted revealed that with prolonged time of exercise, the cadets deteriorated in performing tasks requiring the effort of large muscle groups (running motor adjustment, rotational test and arm muscles strength), whereas tasks involving precise actions (psychomotor performance, forearm muscles force differentiation and shooting) were not affected, or even improved slightly.

Air force cadets performed the running test with a similar score throughout the whole 36-hour experiment, whereas pilots, 15 years older, obtained a lower score at the end of training of the same duration [11]. Soldiers from the special unit presented such a deterioration in performance only at the end of 72-hour survival training [15]. This probably reflects the difference in physical training of different military specialties [22].

With increasing psychophysical workload, Air Force cadets made more mistakes in the rotational test even after only one night of survival training. Neither older pilots nor special units demonstrated such changes after 36 hours of exercise [11]. The first signs of fatigue were observed in the special units just after 54 hours of constant action. Experienced pilots coped better with the rotational tasks due to their unique training involving orientation in space, and practice with special aerial gymnastics equipment.

Decrease in maximal forearm strength after survival training was revealed both in Air Force cadets and military pilots [11], whereas in special units such changes were not observed, even after 72 hours. This is probably due to special forces training, which involves more exercises focused on strength conditioning, including maximal efforts.

A few studies have examined whether the hand-grip strength might be an indicator used for prediction of the results of sport competitions. Such a relationship was not confirmed, but it was noted that it may be relevant in cases of non-sport confrontations, e.g. in the case of a women defending herself against a male aggressor [23, 24]. It should be further investigated whether the performance of soldiers in situations of long-term survival can be linked with hand-grip strength and ability of its differentiation.

The cadets performed the Piórkowski and Cross psychomotor on different levels, and the training undertaken had no effect on the performance of either the Piórkowskiego or Cross tests, performed better with duration of training. This confirms the results obtained in the tests carried out to-date in terms of survival training (visual co-ordination; MCRT) [8, 9, 11]. The study presented psychomotor performance examined by 2 tests: test at the rate imposed and the Cross test. These are classic tools to assess visual motor coordination, speed and accuracy of perception, decision-making under time pressure, and fatigue resistance. Analysis of the results showed that the test at the rate imposed (Piórkowski) did not show statistically significant differences between the resting value, subsequent stages of effort and the rest. The reason may probably be that the Piórkowski test is monotonous, working on the principle of action-reaction without much reflection. The Cross test, however, showed significant differences between the resting value and duration of the training the next day. This is because in the presented study there was greater field stimuli which gave greater stimulation – the greater the number of stimuli, the greater the motivation. Therefore, when there is more motivation, the result is a tendency to improve. Psychomotor performance may be assessed using the most advanced testing and results in a greater involvement in the subjects.

Based on research conducted previously on psychomotor skills by the authors of the current, it can be concluded that long-term military training, coupled with limited possibilities to sleep, does not affect the performance of the tasks associated with short-term concentration (about 90–100 seconds). An issue worthy of further analysis is the examination of how to present the results of studies using psychomotor tests lasting several minutes.

Comparison of results obtained by Air Force cadets with other experimental groups who had similar survival drills revealed that shooting performance was on the same level, whereas non-military students scored poorly [8]. Air Force cadets, like students, with an increasing psychophysical load presented disturbed dynamic balance in the rotational test score already after only one night of survival training. Such changes were not observed even after 36 hours in both special force units [15] and military pilots [11]. During the entire 72 hours of survival training, soldiers of special force units maintained their strength of the forearm muscles, while Air Force cadets presented some disturbances already after 24 hours. All those findings clearly reflect how specialized training translates into differences in real world operations.

Overnight recovery (7–8 hours of sleep) did not result in improvement of maximal forearm strength, its differentiation and dynamic balance. The time obtained in the 15 m sprint (component of running motor adjustment) was longer after the overnight rest. Such a finding reveals that after the prolonged exercise and sleep deprivation, a longer recovery period is required. This is very important information, not only for commanders who will decide, if possible, when to engage soldiers in the next military operation. Also, the designers of the military training programmes should consider a proper balance of workload and recovery in order to avoid overtraining. Excessive and improper military training with a too high psychophysical load will result in the deterioration of soldiers` combat abilities instead of improving them [1]. Probably the introduction should be recommended of overnight survival training sessions on regular basis, at least once every 3 months, in order to familiarize soldiers with action under such conditions.

Considering the nature of energy depletion in the presented study, the best improvements in survival abilities would be obtained by extensive training of strength endurance. Soldiers with better physical fitness are also less susceptible to the lower quality of sleep available [25]. However, it must be considered that not physical fitness and psychomotor performance alone which the value of a soldier on the battlefield. All tasks have to be performed in uniform and with special equipment to which soldiers must be accustomed, even at night and in a state of sleep deprivation. Thus, in order to reproduce as realistic a training as possible, military staff should perform all tasks using the same uniforms and equipment as in real combat situations [26]. Such training will prepare soldiers better for effective execution of military tasks [27]. Further studies are required to establish the strongest correlation between motor abilities and quality of prolonged military action.

CONCLUSIONS

1. Cognitive – 36 hours of survival training combined with sleep deprivation affected coordination performance (hand grip differentiation, results of Rotational test, motor adjustment, heart rate), but not the shooting and psychomotor tests.

2. Application – coordination and strength endurance training should be enhanced in soldiers' drills in order to provide effective execution of precise tasks during military action.

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