Changes in Coordination Motor Abilities of Naval Academy Cadets During Military Survival Training

Andrzej Tomczak; Paweł Różański; Ewa Jówko

INTRODUCTION: Armed conflicts tend to be unpredictable to such an extent that the fact that seamen also have to fight for their survival on land cannot be excluded. The aim of the study was to determine the degree of changes in selected coordination motor abilities in the course of a 36-h military survival training of Naval Academy cadets.

METHODS: There were 14 Polish Naval Academy cadets, ages 20–27 yr, who were examined 4 times: pretraining, after 24 h, posttraining, and after a 12-h rest. Tests related to the following issues were carried out: divided attention, shooting performance, strength of forearm muscles and ability of its differentiations, body balance, and running motor adjustment. During the training soldiers had to perform the following tasks: first aid in the battlefield, building, water crossing to the enemy base, marching to the azimuth, operations in the recon team, and conducting observations.

RESULTS: The maximum strength of forearm muscles during the training decreased from 7–10% during each and every measurement. The ability to differentiate the strength of the forearm muscles after the night part of the training deteriorated (about 9%). There was a systematic deterioration of the ability to maintain balance (between P1 and P4 by 24%).

CONCLUSION: A 36-h training at a survival school varied the selected coordination motor abilities. Training should include exercises that develop an ability to differentiate muscle strength, motor adjustment, and balance. These exercises fall within the scope of coordination exercises that can be performed during obligatory physical education classes.

KEYWORDS: survival, soldiers, sleep deprivation, coordination motor abilities.

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In Poland, getting acquainted with operations performed in isolation constitutes an essential part of a military training for soldiers who are supposed to participate in foreign missions. In the past, trainings of similar nature used to have various names such as existence or survival trainings. These days, similarly to other NATO countries, it is called SERE (Survival, Evasion, Resistance, Escape) and, depending on needs, it is carried out in three different levels of advancement. The basic level is intended for all soldiers, the advanced level is assigned to those who go on foreign missions, and the professional level is for high-risk military individuals.

This phenomenon has also been the theme of scientific research, initially among military pilots, at the Military Institute of Aviation Medicine in Warsaw, Poland. In the 1990s, several important studies were published on survival of military pilots. Scientific employees—specialists in the field of sport sciences, aviation medicine, and psychology—published, mainly in the *Polish Review of Aviation Medicine*, a few important pieces of work on survival school for military pilots. In the following years, scientific research was carried out in cooperation with various centers, including the University of Physical Education, Mossakowski Medical Research Centre Polish Academy of Sciences, and the General Staff of the Polish Army, and the research encompassed soldiers from various formations.[1,17,19] The research was conducted among soldiers with diverse military experience, observing various terrain and atmospheric conditions. In addition, research on a similar subject was conducted by analyzing the civilian environment.[1,15,20]

It is typical of survival school activities to be characterized by a long duration (from several to several dozen hours) and a

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necessity to make various psychophysical efforts. Most of the scientific research on the behavior of soldiers in survival situations has mainly focused on determining changes in psychomotor performance, selected biochemical indicators, cognitive functions, and physical performance/fitness.[14,16] Jówko et al. noticed that a 36-h survival training with sleep deprivation impairs enzymatic antioxidant defense, increases lipid peroxidation, and induces muscle damage.[5] Lieberman et al. established that a SERE training can cause changes accompanied by significant elevations in cortisol, dehydroepiandrosterone sulfate, and neuropeptide Y; a twofold increase in epinephrine and norepinephrine; and an 80-bpm surge in heart rate.[9] Eid et al. found that as a result of the exercise of a simulated war prisoner, Navy cadets experienced symptoms of peritraumatic amnesia, depersonalization, and derealization in response to mild stress. They also exhibited a significant increase in such symptoms when they were later exposed to high stress which stemmed from being placed in a mock POW camp.[3]

The research conducted in Poland shows an attempt to identify changes in coordination motor abilities (CMA) under the influence of the physical effort and sleep deprivation related to a survival training.[2,11,15] Furthermore, the analysis has been concerned with the development of the speed-agility and speed-power ratio/index.[21] Such an approach can be justified owing to the change in the requirements regarding physical fitness of soldiers, and because of the increasing use of advanced technology and electronics in the activities performed by soldiers.

Drozdowski[2] emphasizes that nowadays it is likely for miniaturized electronic equipment to become widespread in an armed conflict. That is the rationale why it will require different motor skills from soldiers. Muscle strength and endurance will be almost eliminated. For the efficient use of modern equipment, the ability to operate devices precisely will be rudimentary.

Human skills and psychomotor skills, despite the evolution of civilization, are still a very important component of efficient human functioning. This approach to the problem applies not only to activities performed by soldiers, but also to everyday functioning of civilians. In the research papers published so far, it has been observed that the level of dynamic balance systematically deteriorates during the whole survival training and with regard to all soldiers, irrespective of their military specialty or age.[16,17,18] On the other hand, no changes have been found during the divisibility of the attention test, which lasted about 90 s.[12,17,18] Deterioration was observed in psychological and biological parameters, including mood change symptoms and stress hormones.[9,13] Diverse test results were revealed during running motor adaptation. After 36 h of the training there were no changes in the soldiers belonging to the special unit and soldiers of very young age (aviation cadets).[16,17,18] However, deterioration in the motor (running) adaptation of experienced pilots was observed.[17]

The present work shows the results of research that were obtained in the course of the Polish Naval Academy cadets' survival training at the Training Center of the University of Physical Education. It may seem unjustified to conduct a survival training in land conditions with seamen. However, armed conflicts tend to be unpredictable to such an extent that the fact that seamen may also have to fight for their survival on land cannot be excluded.

The aim of the research was to determine the degree of changes in selected coordination motor abilities in the course of a 36-h military survival training of Naval Academy cadets. The following hypothesis was put forward: a 36-h survival training with sleep deprivation can cause a significant deterioration of indicators of selected coordination motor abilities, whereas a 12-h rest can return them to their initial state.

METHODS

Subjects

Subjects were Polish Naval Academy male cadets ($N = 14$, age $= 23 \pm 2$ yr, height $= 180 \pm 4.6$ cm, mass $= 79.3 \pm 6.3$ kg, BMI $= 24.7 \pm 1.2$ kg $\cdot$ m^{-2}) with 2 ± 1.5 yr of military service.

Procedure

The research protocol was approved by the Senate Scientific Research Committee of the Józef Piłsudski University of Physical Education in Warsaw (No SKE 01-16/2014). The cadets selected for the training provided their written consent to participate in the research. During the 36-h training, the cadets were deprived of sleep. In total, during the training and the research, the seamen covered 30 km on foot (18 km in the first day, 12 km on the second day) while performing the following tasks: first aid in the battlefield, building makeshift military camps, water crossing to the enemy base, topography, marching to the azimuth, operations in the recon team, and conducting observations. The average air temperature during the training ranged from 1°C to 4°C and it was continuously, yet moderately raining.

The order was adopted using the rule of increasing physical effort in the following tests/attempts. In this way, the effect of the physical effort made in each of the following test/attempt and affecting the result of the test/attempt was eliminated. At the beginning, there was a test that did not require any physical effort (divided attention), then more and more complex tests (shooting, hand grip, dynamic balance) were introduced, ending with the most complex physical structure that necessitated the greatest physical effort.

The research was carried out four times:

P1: immediately before the training;
P2: after 24 h of the training;
P3: after 36 h of the training (completion of training); and
P4: after 12 h of rest (including 7–8 h of sleep).

The description of the tests:

1. Divided attention: two types of signals were displayed on the screen: the first type contained shapes (a square, a circle, or a cross) placed in the central part of the monitor. At the time

when they were displayed in the above sequence, the "+" key was to be pressed with the right thumb (or the "Q" key with the left thumb). All other sequences were incorrect. The second type of signals consisted of small squares displayed in various corners of the monitor. If four squares were displayed simultaneously in one of the corners, the "–" key was to be pressed with the right index finger (or the "l" key with the left index finger). After completion of the test, the numbers of correct attempts were displayed in the central part of the monitor and the number of errors (omitting signals and incorrectly pressed keys) and percent ratios in the corners. The percent ratio of correct reactions to the sum of correct and erroneous ones was the test result.[8]

2. Shooting performance: each participant shot the Zoraki HP 01 Light Pistol at a sports target from a distance of 10 m. The tested participant made five shots, which were then evaluated. Before the test, the participants were advised of safety and aiming procedures. Each participant had the opportunity to give three trial shots.
3. Handgrip strength (in N) was determined with the use of a PZA/3359 dynamometer (Fabrication Enterprises Inc., White Plains, NY, USA) held in the preferred hand, in standing posture, arms along the trunk. Three tasks were performed in order to measure the force differentiation skill: maximum strength, then an attempt at performing 50% of the maximum, then a corrective attempt at performing the requested 50% (without the visual control, with information from the assistant of the result scored after each attempt). Every task was repeated five times and averaged. The results were presented as the maximum force and as relative differences between the actual outcome and the requested 50% value (50% max and correction errors).
4. Dynamic body balance: a rotation test was applied; the participant had to stand on the line, try to perform a jump with a full rotation (alternately clockwise and counterclockwise, repeated three times) and then land with both feet on the line, repeated six times with approx. 12-s intermissions. 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 summarized from six jumps (score range from 0 – excellent to 18 – unsatisfactory).[7]
5. 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 remaining four spaced by 1.2 m; standing start), and 15-m squat (SQ), crouching start. Running times were recorded electronically with 0.01 s accuracy; the results were presented as velocities (15/time) and as standardized values. From those standardized values, the speed-strength (W1) and speed-agility (W2) indices were computed: $W1 = (z_{SS} + z_{SQ})/2$, $W2 = (z_{SR} + z_{SL})/2$.[21]

Statistical Analysis

Statistical calculations were made with the use of Statistica 10.0 (Tibco Software, Palo Alto, CA, USA). The Kolmogorov-Smirnov test was employed in order to evaluate the normality of distribution, and Scheffe's post hoc test and ANOVA one-way analysis of variance or Friedman's test were also performed. Mean results were used. Significance was set at $P \leq 0.05$. Parametric tests were performed for dynamic body balance, shooting, and divided attention. The nonparametric test was performed for hand grip as well as running tests.

RESULTS

The results are presented in **Table I**. The maximum strength of forearm muscles during the training decreased (from 7–10% during each and every measurement). The greatest reduction in the strength of the forearm muscles was found in measurements after the night part of the training (P2) and after 12 h of rest (P4). The ability to differentiate the strength of the forearm muscles after the night part of the training deteriorated (P2, correction, absolute values). Moreover, there was a systematic deterioration of the ability to maintain balance on a statistically significant level during the measurement at the end of the training (by 22%, P3) and after rest (by 24%, P4). According to the adopted criteria, the level of balance changed from medium to low.[7] No differences were found at the statistically significant level in motor adjustment (the running test).

As a result of the analysis of the obtained results, a statistically significant improvement in the divisibility of attention between the initial measurement (P1) and the measurement carried out at the end of the training (P3, by 20.2%) was observed. The divisibility of attention was in the range of 54.6–78.6%.

There were no statistically significant differences in shooting skills. During the shooting, the surveyed participants could get a maximum score of 50 points. The obtained results in individual attempts were in the range of variability between 63–79% of the maximum possible result.

DISCUSSION

Naval cadets are prepared to perform military service in a different manner than land army or air force cadets, so it may be more difficult for them to endure training that is typical for land forces (e.g., SERE). It may have an influence on the results of psychomotor tests and coordination motor abilities of the surveyed participants. This is because the main place of military tasks for naval cadets is the ship and the sea.

According to the study program of the Navy Academy, cadets spend about 1–2 mo at sea after the completion of each year of education. It may seem that such a work environment affects the high level of their ability to maintain balance. This supposition is also justified by the fact that studies carried out by Kalina et al. demonstrate that the highest level of balance skills was observed in equestrian vaulting competitors whose trainings were conducted in conditions where it was difficult to maintain balance.[6] Other activities performed by naval cadets include a significant number of precise manual operations

Table I. Mean Values (± SD) of Handgrip Strength, Running Motor Adjustment, Rotational Tests, Shooting Skills Variables in Polish Naval Academy Cadets ($N = 14$) Participating in Military Survival Training.

VARIABLE	P1	P2	P3	P4
Hand strength (N)				
Max	427 ± 56	389 ± 44*	400 ± 57	386 ± 48
Max/2	213 ± 28	194,5 ± 22	200 ± 29	193 ± 24
50% max	226 ± 41	208 ± 35	214 ± 24	193 ± 26
Corrected 50% max	210 ± 43	190 ± 30	192 ± 20	187 ± 23
50% max	12 ± 36	-14 ± 35	-14 ± 20	0 ± 16
Corr. 50% max	−4 ± 39	-4 ± 34	8 ± 22	-6 ± 15
Abs. 50% max	14 ± 9	31 ± 21*	15 ± 9	13 ± 8
Abs. corr. 50% max	17 ± 14	31 ± 23*	19 ± 14	13 ± 9
Running velocity ($m \cdot s^{-1}$)				
15 m	5.73 ± 0.52	5.58 ± 0.48	5.79 ± 0.57	5.77 ± 0.34
3 × 5 m	2.66 ± 0.10	2.76 ± 0.23	2.79 ± 0.16	2.87 ± 0.16
15-m slalom	3.71 ± 0.30	3.54 ± 0.26	3.79 ± 0.31	3.67 ± 0.41
15-m squat	2.98 ± 0.42	2.90 ± 0.30	3.07 ± 0.46	2.98 ± 0.49
W1	1.08 ± 0.76	1.27 ± 0.76	1.77 ± 1.16	1.48 ± 0.52
W2	2.09 ± 0.96	2.03 ± 1.14	2.27 ± 1.10	2.17 ± 0.95
Divided attention				
Scores (%)	58.4 ± 13.0	54.6 ± 18.0	78.6 ± 9.2‡	57.6 ± 12.3
Rotational test				
Scores (points)	6.2 ± 2.6	8.5 ± 5.5	10.4 ± 5.3**	10.8 ± 3.8†
Shooting				
Scores (points)	39.5 ± 15.6	31.5 ± 17.0	32.9 ± 19.0	36.9 ± 15.4

*Significantly ($P < 0.05$) different between P1–P2; **Significantly ($P < 0.05$) different between P1–P3; †Significantly ($P < 0.05$) different between P1–P4; ‡Significantly ($P < 0.05$) different between P3–P1, P2, P4.

resulting from the handling of specialized equipment on the ship. The service of the ship also requires a significant concentration of attention and resistance to stay in a relatively small space for a long period of time. It is possible that being in such conditions of service can have an effect on the psychomotor and coordination abilities that are necessary during SERE operations on land. The objective of the study was to prove the hypothesis that a 36-h survival training with sleep deprivation would cause retention of the initial state. The hypothesis failed to be confirmed. The training did not have an adverse influence on the divisibility of attention, the speed test of motor adaptation, or shooting. In turn, a 12-h rest did not improve (return to the initial state) dynamic balance.

The further part of this study provides a comparison of coordination changes in motor skills of air force cadet officers[18] and naval cadet officers, who participated in survival school classes of similar nature (duration, physical load, sleep deprivation, training subject). This comparison is noteworthy because both groups of soldiers were prepared for service in a completely different environment that is not on land. One group concerned air force pilots, whereas the other seamen for naval services.

Therefore, preparations for land operations as part of the school of survival are a peculiar experience for them. However, this kind of training is more useful for military pilots because of the possibility of their aircraft coming down over enemy territory, and thus its emergency landing in contingent terrain, which involves a risk of capture and isolation (SERE).

A classic example of such an event is the history of Capt. O'Grady, an American pilot shot down over Bosnia in 1995.[12] In addition, in previous research observations, it was found that aviation cadets (future jet plane pilots) are characterized by a greater maximum strength of the forearm muscles. However, when comparing both populations of surveyed soldiers in the scope of the ability to differentiate forearm muscle strength, this task was performed by naval cadets at a higher level (error correction 50%).

Deterioration in the ability to maintain balance was found in both cadet groups. It should be noted, however, that Air Force cadets were characterized by a high initial balance level (3.2 points), which deteriorated to the average (6.7 points) during the training.[18] Meanwhile, naval cadets demonstrated an average initial level of balance (6.2 points), which at the end of the training decreased to the low level (10.4 points). It is puzzling what factors have influenced such a large variation in the initial levels of maintaining balance. It might have been influenced by previous experience related to doing aerial sports, during which disturbances of the sense of balance are more frequent. In order to thoroughly verify the problem described above, further research is essential. Naval cadets performed the same divisibility of attention test as military pilots and soldiers of the special unit.[16,17] They performed the test during the training at a higher level than before it had started. A similar relationship was observed in the research conducted during the training of special unit soldiers.[7] This situation is justified by the Yerkes Dodson Law, according to which psychological burden may affect the performance of tasks in the following way:[10]

- As physiological arousal rises, it becomes easier to perform a given activity/task, but only to a certain level. Later, there is only a decline in efficiency, which leads to extreme disintegration of behavior in an extreme situation; and
- For difficult tasks, the optimal level of arousal is lower than for those which are easy. According to this law, it can be assumed that during the implementation of long-term tasks in the course of the SERE training that do not require any significant physical effort, tasks can be performed in a correct manner. It is difficult to unequivocally determine when the operations will be done properly and when deterioration will start. Further research is required to clarify this matter.[10]

Different results were obtained by Heaton et al., who conducted an attention and visual tracking study on a group of 87 soldiers.[4] They were deprived of sleep for 26 h, but did not perform any intensive military training. It would indicate that in conditions of very real training (SERE), according to the

Yerkes-Dodson Law, soldiers are able achieve a significant concentration of attention while performing difficult tasks. This is confirmed by the results of tests of shooting skill, which despite the physical effort, did not deteriorate. An all-night rest (7–8 h of sleep) of the Naval Academy cadets did not fully contribute to the recovery (return to the initial stage) of the maximum strength of the forearm muscles and balance. For other variables, this length of rest was sufficient.

The above data are important for commanders who have to make decisions regarding the next tasks assigned to soldiers who have just finished performing other long-term tasks. The age of the surveyed soldiers and their military specialty should be taken into account, because, as shown by other studies, the age of the respondents has an impact on the change of CMA and recovery of physical forces.[16–18]

The presented results of the changes in CMA during the survival school training conducted among the Naval Academy cadets are unique. Considering the real necessity of seamen who operate on land during armed conflicts, it is justified to conduct such a training. It seems that it is advisable from the point of view of the physical training of the Naval Academy cadets to introduce exercises that help to differentiate muscle strength, motor adaptation, and balance. These exercises fall within the scope of coordination exercises that can be performed during obligatory physical education classes (topics: team games, track, and field).

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