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Research article

Effective Methods for Optimizing Effort Capacity in the Military Pentathlon Event

Dumitru Cătălin Cohal [1]

1 Doctorand Universitatea Lucian Blaga Sibiu, Romania;

* Correspondence: cohalcatalin@gmail.com

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Abstract: he military pentathlon is a complex test of physical and mental endurance that challenges military athletes in the events of shooting, obstacle swimming, obstacle running, grenade throwing, and endurance running. My personal experience inspired me to develop a comprehensive, individualized, and scientifically grounded training program aimed at optimizing competitive performance and providing a scientific foundation for military pentathlon training in Romania. Through precise physiological monitoring, personalized training cycles can be established to cover all five events and enhance each athlete's individual effort capacity. This article explores modern physical and mental training methods, with a focus on adaptability and injury prevention. It also examines the benefits of using performance-monitoring technologies to adjust training intensity in real time. I employed functional tests such as the Balke-Ware protocol and Garmin HRV technology. The working methods included literature review, experimentation, and observation. The literature review provided the theoretical foundation, while observational and experimental methods enabled real-time data collection. Through statistical analysis, the data obtained from these methods were interpreted. The results show a significant increase in athletes' effort capacity. This research demonstrates that personalized training cycles can significantly improve athletic performance and extend the longevity of a sports career.

Keywords: military pentathlon, effort capacity, personalized training

1. Introduction

Military pentathlon is an athletic event composed of five distinct disciplines specific to the military environment. Pentathletes are true athletes, displaying exceptional physical and moral standards, in line with the versatility that defines this discipline. Pentathlon is the first combined athletic event in the history of sport and the second athletic discipline featured in the ancient Olympic Games. Its organization in ancient times significantly influenced the evolution of human society. The multidisciplinary nature of the pentathlon led to the emergence of gymnasiums and palestrae, organizational discipline, coaching, and the development of sports science specialists. Over time, athletic performance standards have often been referenced through the lens of pentathlon. While pentathlon is widely known in the sports world through the Olympic modern pentathlon, there are also three types specific to the military domain: military, navy, and aeronautical pentathlon. Military pentathlon competitions are athletic contests organized internationally under the aegis of the International Military Sports Council (CISM) [1]. These events promote human moral values, respect, and camaraderie among soldiers from different armies and countries, serving as a bridge between military communities and the broader civilized world. Humans began to

perceive their existence on Earth in a more organized and systematic manner, incorporating the importance of regular physical training. In antiquity, the pentathlon included five events with a military character: javelin throw, discus throw, long jump with weights, sprint, and hand-to-hand combat[6]. Today's pentathlon presents a modern version of the discipline, allowing athletes to express their versatility in a way suited to the modern Olympic arena. Military pentathlon honors the ancient tradition by providing military personnel with the opportunity to display the physical and mental attributes essential for a well-prepared, multidisciplinary soldier. The five events of military pentathlon are shooting with a fire gun, hand grenade throwing for distance and accuracy, obstacle swimming, obstacle course running, and cross-country running. Romania is a member of CISM and, since 1998, has actively participated in international military and aeronautical pentathlon competitions. At the national level, military pentathlon competitions are regularly organized within the Ministry of National Defense[3]. The next step in Romania's involvement in such events would be the organization of international military-specific pentathlon competitions in our country. Achieving this goal requires not only the development of specialized facilities for hosting such events but also a high level of expertise among those involved in the selection and training of military pentathletes. Committing to participation in these competitions entails meeting athletic performance standards in line with the tradition of the ancient pentathlon. An international-level military pentathlon team consists of five men and four women. To qualify for the Military World Championship, male athletes must accumulate a total of 4750 points, while female athletes must reach 4450 points. The military pentathlon regulations allow organizers to hold the events either on separate days or two events in one day, depending on the number of participants. For example, the shooting event may be held on the same day as the obstacle course, the swimming event can be paired with grenade throwing, and the final event is usually the cross-country run. When competitions are spread over five days, a relay event on the obstacle course is also organized. Military pentathlon is a complex athletic discipline, where interactions among its various components like physiology, technique, and strategy in shooting, swimming, grenade throwing, and also running play a crucial role in determining an athlete's overall performance[13,14]. Although military pentathlon has been included in the sports training calendar of Romanian military personnel, their performance levels have yet to reach the desired standards. Specialists in the field have tended to focus more on endurance events, but pentathlon requires more than just endurance. There is now a need to accept and apply new research studies that define the typology, physiology, and anthropometry of military pentathletes, as well as updated competition strategies. Applied research studies conducted on groups of military pentathletes who have achieved notable results in competitions are essential for understanding the elements that influence varying levels of performance. It is also important to distinguish between the performance of male and female military pentathletes, as well as how they are selected. In Romania, military pentathletes are selected from among active-duty military personnel. In other countries, however, military pentathletes are recruited also from outside of the military organization through physical testing and then enlisted as military members. Selection plays a critical role in achieving high performance. In order to develop effective training methods and programs it is essential to identify young individuals with the potential to become elite athletes within the military environment[12].

2. Research Objectives

The importance of optimizing effort capacity for performance and injury prevention represents the central aim of this research. For the military pentathlon coach, the primary goal throughout the training plan is to achieve the desired performance level for each individual athlete, as well as for the team as a whole. This research supports the coach's work by increasing efficiency and establishing clear scientific benchmarks

upon which they can rely in their practice. Just as today's society is heavily influenced by technology in nearly every field of activity, sport also demands a technical, scientific, and personalized approach in the development of training methods and plans. Effort capacity refers to the maximum level of physical activity that an athlete can sustain efficiently, without compromising recovery or significantly increasing the risk of injury [9]. It encompasses components such as: aerobic and anaerobic endurance, strength and speed, joint mobility, and recovery ability. An optimal effort capacity enables athletes to maintain a high level of performance throughout the entire competition. Individually adapted and personalized training helps delay the onset of fatigue after completing all five events. They are also a determining factor in maintaining concentration and precision during the shooting and grenade throwing events, as well as coordination during the running or obstacle swimming events[7]. This study presents realistic analyses that outline how training influences effort capacity and how these changes affect the performance of military pentathletes. This goal is achieved by examining variations according to the level of preparation, age, and competition experience of the military pentathlete—whether male or female. Another objective is the development of a personalized, results-based training plan so that at the time of the competition, the military pentathlete reaches peak form across all five disciplines. Maximal oxygen consumption (VO2max) is considered a benchmark for evaluating cardiovascular capacity[2,8]. The existence of a sports medicine laboratory equipped with specialized technology for determining effort capacity is essential for obtaining accurate VO2max measurements. These tests also require time and must be integrated into the athletes' annual training plans so that they fulfill their purpose. Improving the efficiency of effort in each individual event is closely tied to the technical approach taken in each discipline. Even running can be optimized, despite most military pentathletes being selected from endurance or middle-distance track events[4,10]. The running required in the obstacle course demands a specific endurance technique that combines strength, skill, and speed. Maintaining these qualities and developing the others required for the throwing or swimming events to reach desired performance levels are outcomes of modern training methods. Evaluating the effectiveness of physiological monitoring in building personalized training programs, creating an integrated training protocol to optimize effort capacity, and validating the impact of these methods through measurable results (functional tests, competition performances, etc.) are modern physical and mental training approaches applicable to the military pentathlon[5].

3.Research Hypothesis

The implementation of a personalized training program based on physiological monitoring will lead to an increase in effort capacity and, consequently, in the performance level across the five events of the military pentathlon.

4. Discussion

The findings of this study underscore the positive impact of the applied physical effort optimization strategy in the context of the military pentathlon. The observed improvements in participants' physical performance support the initial hypothesis that a structured training program—grounded in modern principles such as individualization, effort monitoring, and the modulation of training volume and intensity—can significantly enhance both general and event-specific endurance capacity. The incorporation of functional exercises, high-intensity interval training (HIIT), and systematic recovery monitoring proved effective in preventing overtraining, reducing injury risk, and facilitating sustained physiological adaptation. A key strength of the

intervention lies in its tailored alignment with the specific demands of the military pentathlon, a complex, multifaceted discipline that requires the integration of skill, endurance, speed, and strength. The success of the program highlights the necessity of a multidimensional approach to training design, particularly in disciplines with such diverse physiological and technical requirements. Nonetheless, the study is not without limitations. The sample size was relatively small and limited to elite-level military pentathlon athletes, potentially affecting the generalizability of the results. Furthermore, the intervention was conducted over a relatively short period, and lacked psychological and nutritional assessments, which could have provided a more holistic perspective on performance optimization. Future research should aim to address these limitations by involving larger and more diverse participant groups, extending the duration of interventions, and incorporating additional performance-influencing factors such as operational stress management and sleep optimization. Such approaches may yield deeper insights into the complex mechanisms that drive athletic performance in military-specific contexts.

5.Methodology

- study of key scientific research related to the subject of the investigation;
- presentation of data analysis and statistical processing methods;
- identification of scientific research methods applicable to a combined event with military specificity;
- establishment of research groups;
- development of a training program for optimizing effort capacity;
- definition and implementation of physical tests to be applied in the initial and final assessments in order to determine the effort capacity level of military pentathletes.

5.1. Research Subjects

This research was conducted with the participation of 6 athletes competing in the military pentathlon, aged between 25 and 31 years (with an average age of 27.8 years), consisting of three men and three women, all having over 6 years of competitive experience with outstanding results at military pentathlon world championships (Table 1.1.). Written consent was obtained from the tested athletes whose results were included in this research, as well as from the military institution to which they belonged. The participants were informed about the purpose and nature of the study. Their participation was voluntary, did not interfere with their training process, and did not impose any constraints on them or the institution. Additionally, the six subjects were informed that the evaluation results would be used in a research paper without disclosing their names or the name of the institution they belong.

Tabel 1.1. Research subjects

Subjects	Sex	Competitions experience (Years)	Age (Years)
1	M	6	25
2	M	6	25
3	F	9	27
4	M	8	29
5	F	10	30
6	F	10	31
Total= 6	3xMale; 3xFemale	∑= 8,16	∑=27,8

5.2. Instruments and Technologies

- Functional tests: the Balke-Ware test for estimating VO2 max [2].
- Monitoring technology: Garmin HRV smartwatches, treadmills equipped with pulse measurement sensors.

6. Implementation Plan

The applied tests were conducted between February and June2024. Early April 2024 was chosen for the initial testing (IT), with athletes returning from the winter break (called the transition period and the beginning of the training period), and at the beginning of June (the pre-competition period) the final tests (FT) were administered. The tests did not affect the training periodization. In the military pentathlon event, reaching the performance level coincides with the moment when training reaches the highest effort levels, but the training duration decreases, giving the body that extra energy reserve that will make the difference. The locations for the tests and training programs were: a gym equipped with a treadmill, a CISM-type obstacle track, a 50-meter swimming pool with obstacles specific to the military pentathlon event, running trails on varied terrain without difficult obstacles and with a maximum slope inclination of 4%. This research deeply analyzed those aspects of physical preparation of military pentathletes with a high level of athletic performance. During the three months of training before the Military Pentathlon World Championship, the tested athletes had a training frequency between nine and twelve sessions per week. The average weekly training duration varied from approximately 10.5 hours/week at the beginning of the training period, reaching 16.3 hours/week one month before the competition, then decreasing to 8 hours/week before and after the competition. Coaches focused on allocating significantly more training time to athletes who had deficiencies in technical events (shooting, obstacle course, and swimming), reducing the time allocated for the running event[9,10,11]. The time dedicated to preparation for the precision grenade-throwing event was not calculated. Athletes threw grenades daily for 30 minutes before lunch, practicing precision. Specific strength training for the throwing events in athletics is included in the calculations mentioned above. To maximize the athletes' competitiveness, a carefully controlled training program was developed together with all the event specialists and differentiated for each athlete individually, so that peak performance coincides with the targeted competition. The research was divided into stages to provide a clear structure for applying the tests, allowing athletes to have an exact understanding of their training schedule.

Stage	Activity	Period
I.	Theoretical documentation	Weeks 1–2
II.	Selection and initial testing of subjects	Week 3
III.	Implementation of the training program	Week 13
IV.	Data collection and analysis	Weeks 13–14
V.	Interpretation of results and writing conclusions	Weeks 15–16

In the first stage, I conducted theoretical research on training for combined events, which I then integrated[10]. The Balke-Ware test was applied both at the initial and final phases of the study. Although the Balke-Ware test is a submaximal effort test, it is frequently used to evaluate aerobic capacity and estimate VO_2max (maximum oxygen consumption) without the need for sophisticated testing equipment. The calculation formulas from the Balke-Ware protocol are:

1. Male: $VO_2max = 1.444 \times T + 14.99$
2. Female: $VO_2max = 1.38 \times T + 5.22$

The IT duration it was set to 10 minutes, during which the athletes ran at a steady pace on a treadmill in the sports hall, with the treadmill incline adjusted every minute according to the data in Table 1.2.. All the athletes managed to reach level 10, with the mention that the effort required for the final level was substantial. 4 out of 6 athletes would have completed a potential new level. One of the girls being able to endure for one more minute. For the final test, the time was 15 minutes. All the athletes managed also to pass the test. Throughout the both test, the athletes' heart rate was measured. Expected results include increased overall effort capacity and in specific events where the athlete can improve, reduced recovery time and injury rates, and improved monitored physiological parameters.

Table 1.2. Balke-Ware Test (IT) and Table 1.3. Balke-Ware Test (FT)

Level	Min.	Inclination	Speed	Heart rate average
1	0-1	1 %	0-15km/h	112 bpm
2	1-2	2 %	15 km/h	117 bpm
3	2-3	3 %	15 km/h	123 bpm
4	3-4	4 %	15 km/h	144 bpm
5	4-5	5 %	15 km/h	149 bpm
6	5-6	6 %	15 km/h	156 bpm
7	6-7	7 %	15 km/h	168 bpm
8	7-8	8 %	15 km/h	179 bpm
9	8-9	9 %	15 km/h	186 bpm
0	9-10	10 %	15-0 km/h	193 bpm

Level	Min.	Inclination	Speed	Heart rate average
1	0-1,5	1 %	0-15km/h	110 bpm
2	1,5-3	2 %	15 km/h	119 bpm
3	3-4,5	3 %	15 km/h	120 bpm
4	4,5-6	4 %	15 km/h	141 bpm
5	6-7,5	5 %	15 km/h	147 bpm
6	7,5-9	6 %	15 km/h	155 bpm
7	9-10,5	7 %	15 km/h	167 bpm
8	10,5-12	8 %	15 km/h	178 bpm
9	12-13,5	9 %	15 km/h	188 bpm
10	13,5-15	10 %	15-0 km/h	196 bpm

7. Result

Descriptive statistics: to interpret the results obtained in the evaluation tests, the main indicators of descriptive statistics were calculated for both the initial testing (IT) and final testing (FT). Specifically, it was analyzed whether the average heart rate at FT showed positive changes and whether the maximum oxygen consumption improved. The test results show that the average difference between the initial testing and the final testing for Male is 7,29 and for Female 6,9 . This shows a significant increase in the maximum oxygen volume and also a significant decrease indicating improved cardiac efficiency considering that in the final phase the athletes ran consistently for 5 minutes longer than in the initial phase. Heart rate average between the initial testing and the final testing − ∑= 152,7 – 152,1= 0,6 bpm.

1. Balke-Ware Initial Testing (IT) for Female: $VO_2max = 1.38 \times 10 + 5.22=19.02$
2. Balke-Ware Initial Testing (IT) for Male: $VO_2max = 1.444 \times 10 + 14.99=29.39$
3. Balke-Ware Final Testing (FT) for Female: $VO_2max = 1.38 \times 15 + 5.22=25.92$
4. Balke-Ware Final Testing (FT) for Male: $VO_2max = 1.444 \times 15 + 14.99=36,65$

Table 1.3. Descriptive statistics – experimental group results – assessment of heart rate and VO_2max (baseline and end-point testing)

Statistical indicators	Heart Rate (IT)	VO_2max (IT)	Heart Rate (FT)	VO_2max (FT)
N	6	6	6	6
M-Average	152.7	33.71	152.1	44.24
S-Standard deviation	0.52	2.3	0.43	2.5
Cv- coefficient of variability	0.34	6.8	0.28	5.6

Table 1.3. presents the values of the main descriptive statistics indicators for the research group, for the Balke-Ware evaluation sample, along with the average heart rate for both the initial and final test. The values of the main statistical indicators are: the mean (M), standard deviation (S), and coefficient of variability (Cv) for the research group (athletic intervention), for heart rate and maximum oxygen volume coefficients, both (N=6). In the initial test, regarding heart rate, participants recorded an average of 152.7 beats per minute, S = 0.52, Cv = 0.34, indicating that homogeneity is ensured. As for the maximum oxygen volume, the average result was 33.71, S = 2.3, and Cv = 6.8, with results also being similar to each other. In the final test, regarding heart rate, participants recorded an average of 152.1 beats per minute, S = 0.43, Cv = 0.28, which shows that homogeneity is ensured, with participants having close results. For maximum oxygen consumption, the average result was 44.24, S = 2.5, and Cv = 5.6, with similar results at group level.

8. Conclusions

Following the application of this research, it can be stated that training for the military pentathlon event must be developed in a personalized manner and within intervals that allow the athlete's physical and mental capacity to adapt to the intensity of activities in the five disciplines. By utilizing training sessions that alternate periods of active recovery with workouts of variable intensity and high-effort intervals, a significant contribution can be made to increasing the military pentathletes effort capacity. Structuring training into cycles, optimizing technique, and identifying the optimal moment to reduce effort intensity during the pre-competition period all lead to maximizing athletic performance. Therefore, good planning of training sessions, taking into account those physical preparation indicators that can add value to the athlete in disciplines where performance can be substantially improved. Combined with the implementation of active recovery and rest periods at the right time helps prevent overtraining and injuries, and can improve performance during competition

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