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WEB APPLICATION FOR CONTROL OXYGEN REGIMES OF THE BODY

Introduction. *The muscular fitness of servicemen plays a significant role in the successful performance of military and professional tasks. Currently, 60 days are allotted for the training of a serviceman, so the task of optimizing this training is urgent. Typically, strength endurance can be effectively improved by combining strength, aerobic, and specific weight training. Therefore, the task of objective control of the training process is urgent. A number of sources emphasize the connection between the injuries of military personnel in the* *conditions of professional activity and aerobic productivity. That is why a model of regulation of the body's oxygen regimes was chosen for the purpose of training control. The need to process large amounts of information justifies the need to develop convenient applications for this.*

The purpose of the paper *is to develop a web application for monitoring the training process of military personnel based on the model of managing the body's oxygen regimes.*

Methods. *Mathematical modeling methods, programming methods.*

Results*. The developed web application for modeling the oxygen regimes of the body allows for objective control of speed and strength training of military personnel. The web application is developed on the OpenXava platform, which provides the user with a more convenient service, is suitable not only for the Windows operating system, but also for Linux, Mac, UNIX, Android and does not require the installation of additional software.*

Keywords: *mathematical model of regulation of oxygen regimes of the body, professional military activity, speed-power training of the military.*

INTRODUCTION

In Ukraine, the requirements for the physical training of military personnel are based on criteria for assessing the physical fitness of military personnel of NATO countries.

The speed-strength physical qualities of combatants are among the leading ones for achieving military goals. Strength training can be aimed at developing various types of strength qualities — maximum strength; speed strength — the ability of the musculoskeletal system and its structures to achieve high levels of strength in the shortest possible time; strength endurance, which characterizes the ability of the human body to maintain sufficiently high strength indicators for a long time.

Basic military tasks that require physical effort include cargo transportation, manual loading and unloading, and casualty evacuation. Lifting requires both aerobic and neuromuscular training, with a heavy emphasis on maximal strength and absolute maximum oxygen consumption, especially when carrying heavier loads. In manual materials handling, maximum strength and power are closely related to discrete lifting performance, while muscular strength, muscular endurance, and aerobic fitness are also related to repetitive lifting performance. Maximum strength, including grip strength, muscular endurance, absolute maximum oxygen uptake, and anaerobic capacity are associated with the effectiveness of casualty evacuation. In [1], the role of muscular preparedness in the successful completion of the considered military professional tasks is especially emphasized. Intervention training studies show that strength endurance can be effectively improved by combining strength, aerobic, and weight-specific training. Improvements in maximal lifting capacity can be achieved through strength training or combined strength and aerobic training, while strength and aerobic training alone or a combination of both is effective for improving repetitive lifting and task performance. Only a few studies are available on casualty evacuation, and the results are inconclusive, but may indicate benefits of strength or combination training [2]. Additionally, an emphasis on lower volume but higher intensity in combined training may be a feasible and effective way to improve the military competencies of recruits and active-duty military personnel.

The development of physical qualities involves various methods of a static and dynamic nature and, consequently, the development and improvement of neurohumoral mechanisms of regulation of not only intra- and intermuscular coordination, but also the development of aerobic and anaerobic mechanisms for energy supply of the functions of the musculoskeletal system (MSS) [3].

Physical activity affects not only the musculoskeletal system, but also all internal systems of the body. Motor-visceral reflexes are somato-visceral reflexes in the form of changes in the functions of any internal organs or organ systems during physical exertion on the musculoskeletal system [3].

During human physical activity, impulses from proprioceptors (receptors of muscles, tendons, joints) radiate along nerve fibers to internal organs, increasing their activity in accordance with the load on the musculoskeletal system. This creates a training effect not only of the musculoskeletal system, but also of the autonomic systems and, first of all, the circulatory system, blood system, respiratory system, i.e. functional respiratory system (FRS). Such adaptation of body systems increases the efficiency of energy supply to working skeletal muscles and their physical capabilities, which in the process of training (repetition of optimal loads) leads to the efficiency of FRS functions [4]. The most important components of military training are presented (Tabe 1).

The performance and military preparedness of a serviceman, in accordance with [1], is determined by a number of factors (Fig. 1). Aerobic performance, in particular oxidative phosphorylation, is the most efficient and economical process of ATP formation compared to glycolytic processes in the human body. The implementation of oxidative phosphorylation completely depends on the state and development of FRS and its component — the ORB regulation system [4].

Note that there are many publications related to attempts to optimize the training process of military personnel in order to meet the unique requirements of professional military activity. It is shown that a large amount of physical training jeopardizes the development of muscle strength [2]. Inappropriate recovery periods with such high levels of physical stress can lead to suboptimal training and an increased risk of injury in military personnel [5]. Therefore, modern publications pay great attention to finding effective ways to train.

Thus, a systematic review [6] identified the effects of exercise on various domains of physical fitness (e.g., aerobic fitness, flexibility, muscular endurance, muscle strength, muscular strength, and occupational performance) that influence occupational performance and risk musculoskeletal injuries among military personnel. The studies described in this review consisted of comparison groups of healthy military personnel performing traditional and nontraditional military physical training, with at least one representative assessment of the physical fitness domain.

Table 1. Components of military training

Components of military training		
physical	technical-tactical	mental

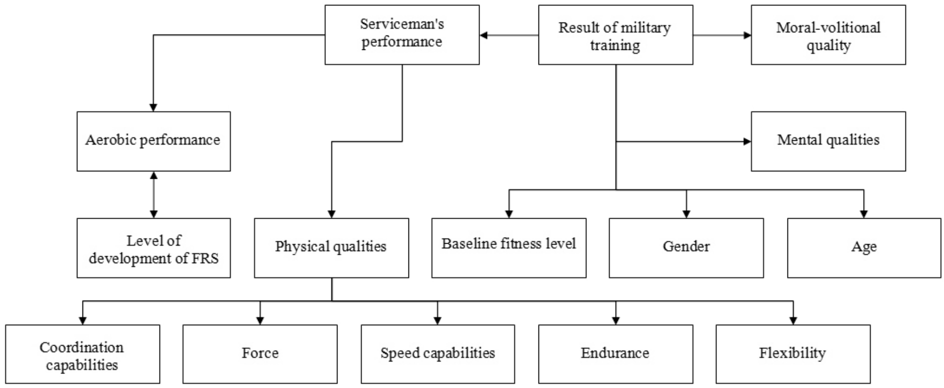

Fig. 1. Factors determining the performance and preparedness of military personnel

A systematic review showed that non-traditional military physical training has a greater post-training effect on muscular endurance, power, strength measured through maximum repetitions, and occupational-specific physical performance compared to traditional military physical training. Overall, these findings suggest that nontraditional military physical training may be beneficial in optimizing occupational performance, potentially reducing the risk of musculoskeletal injuries.

Another challenge facing the armed forces in recruiting physically capable soldiers is the deterioration of physical fitness and the increase in body fat among young people. A review [7] emphasizes that knowledge about optimizing physical adaptation and performance through exercise training is vital. Additionally, maintaining or improving the physical performance of professional soldiers in a variety of military environments is critical to overall combat readiness. This review focuses on the impact of military training on physical performance by searching for optimal methods for this. Military training primarily consists of long-term physical activity and low-intensity training, which can interfere with optimal muscle strength and address the development of maximum strength, power, and aerobic capacity. Combined endurance and strength training appears to be the best training method for improving the overall physical performance of soldiers. Research has shown that military training requires a greater variety of training stimuli to induce more effective training adaptations, especially when considering the development of maximal or explosive strength and maximal aerobic capacity. Training programs should be well periodized so that the total training load increases progressively, but also includes sufficient recovery periods. In addition, some individualized programming is required to avoid unnecessary injury and overuse, since differences in the initial physical fitness of soldiers can be very large.

The same questions are raised in [8]. The purpose of military basic training (MBT) is to build a foundation of physical fitness and military skills for soldiers. You can then safely undergo more advanced military training. Large differences in the initial physical fitness of conscripts or recruits have prompted military units to develop safer and more effective training programs. The purpose of this review article was to describe the limiting factors of optimal physical fitness during BT. This review found that high volumes of low-intensity physical activity combined with military endurance training (e.g., combat training, sustained exercise, and field marksmanship) during BT interfere with the optimal development of maximal oxygen consumption and muscle strength in soldiers. Therefore, more progressive, periodic and individualized training programs are needed. In conclusion, optimal training programs result in higher training response and reduced risk of injury and overuse.

The US Armed Forces recently approved the full inclusion of women in combat roles. Presentations from the 2014 DoD Symposium on Women's Health in Combat, focusing on physiological, musculoskeletal injuries, and optimized physical fitness considerations from the operational physical performance section is summarized [10]. The symposium was held to present the current state of the science on the US Department of Defense's reversal of the ground combat exclusion policy opening combat professions to women. Physiological, metabolic, body composition, bone density, cardio respiratory endurance, and thermoregulatory differences between men and women were briefly reviewed. Epidemiological injury data from military training and combat indicate that women are at higher risk for musculoskeletal injuries than men. Physical fitness considerations were also addressed to improve muscle strength and power, performance of occupational tasks, and load bearing. Particular attention in this article was given to translating the physiological and epidemiological data from the literature on these topics into actionable guidance and policy recommendations for those responsible for military physical fitness doctrine (Fig. 2).

A study [11] compared the physical demands and basic training progression of male and female British Army recruits in single-sex platoons.

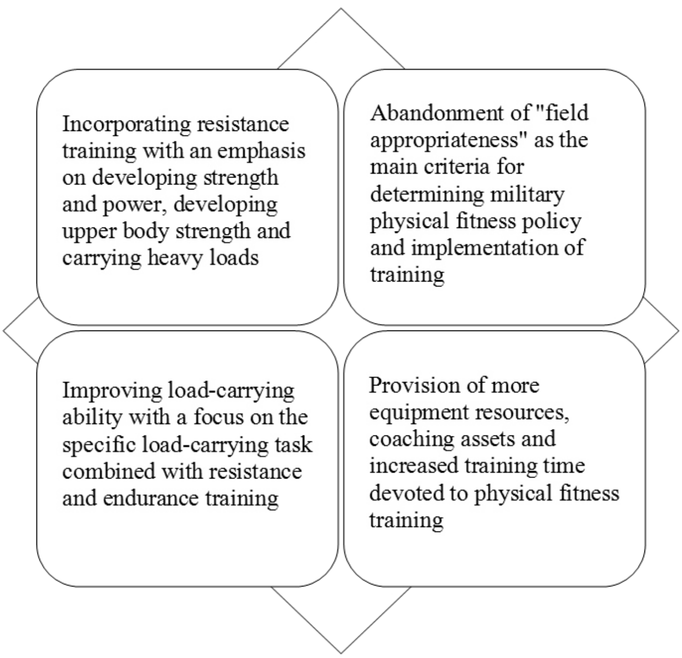

Fig. 2. Recommendations for improving the effectiveness of physical training of military personnel

Gender differences in the physical demands of British Army recruits training in three platoons with different gender compositions are examined [12].

The results of studies of the same direction were carried out in the Australian [13] army and the US army [14]. The goal was to determine, given the inherent physiological and physical differences between men and women, whether sex differences exist in adaptation to military training and, therefore, whether sex-specific training should be used to optimize training adaptation.

Research has shown that improvements in some, but not all, components of performance were observed after a period of military training, but these improvements did not differ significantly between genders. Although the absolute physical demands of basic training were greater for male recruits, the relative cardiovascular demands were similar for both sexes. Therefore, the authors conclude that further research is needed to evaluate sex differences in response to physical training under controlled conditions to improve military physical training outcomes for both sexes.

The work [15] aimed to determine age and sex differences in physical fitness indicators in the conditions of basic training and the active US Army. Male basic training and active duty soldiers have been determined to outperform their female counterparts in tests of muscular and cardio respiratory endurance. Gender differences in physical performance among female soldiers in operational units have decreased compared to soldiers who have completed basic military training. Among male soldiers, infantry soldiers demonstrated higher cardio respiratory and muscular scores than non-infantry soldiers. Overall, it has been suggested that differences in cardio respiratory and muscular performance between men and women should be addressed through targeted physical training programs aimed at minimizing physiological differences.

The results of a very interesting study are presented in [16]. A unit of 756 men and 474 women undergoing US Army Basic Combat Training (BCT). Testing included running on a treadmill at maximum oxygen consumption ($q_t O_2$ max) and vertical jumps, and measuring muscle strength. Multivariate analysis showed a relationship between oxygen consumption rate and the likelihood of injury when using a standardized physical training program, although the authors emphasize the need for further research in this direction.

The functional capabilities of the gas transport system of a serviceman's body, like any other individual, determine physical performance and, consequently, performance in professional activities. It should be taken into account that the gas transportation system consists of a complex of links, the parameters of which determine and limit its functionality, and, accordingly, physical performance [4].

In addition, significant factors influencing the performance of the gas transportation system are the nature of muscle activity, specialization, power zones and associated energy supply systems. The achievements of modern physiology, biochemistry and other natural sciences have made it possible to get closer to assessing the individual stages of mass transfer of respiratory gases under different conditions and stresses of the body. It seems justified to use a systematic approach that allows one to analyze the process of mass transfer of respiratory gases in the body and establish connections between the nature of physical stress and internal changes that regulate this process.

For the physical training of military personnel, it is advisable to use theoretical and practical experience gained in the training of athletes who are professionally involved in sports. Sports activity is primarily associated with training and competitive loads of extreme intensity and duration, during which metabolism and oxygen consumption increase many times over. Ensuring increased oxygen consumption during muscle activity is accompanied by increased activity of all parts of the gas transport system, including external respiration, cardiovascular system, and blood and tissue respiration. The reserve of these links largely determines the level of oxygen consumption rate (q_tO_2) and overall physical performance. Depending on the type of training load, specific adaptation mechanisms of the body are formed, which determine the reserve of individual parts of the gas transport system, metabolic features, resistance to hypoxia etc. The specifics of training loads, their volume and intensity in various types of activity suggest the formation of various mechanisms of adaptation of the body to loads, including the level of metabolism, changes in the functional reserves of individual parts of the gas transport system and general physical performance.

Research [17] proposes the construction of model profiles of athletes of various sports qualifications based on a set of average values of the most informative parameters of the gas transport system (respiratory rate, tidal volume, minute respiratory volume, ventilation equivalent, heart rate, stroke volume, minute blood volume, hemodynamic equivalent, maximum oxygen consumption, arteriovenous difference, hemoglobin content in the blood, acid-base state of the blood), characterizing the functional state and performance of athletes of a certain level of training. The constructed model profiles are intended to be used as normative characteristics in the comparative assessment of individual functional capabilities, which will make it possible to analyze studies on physical training interventions in military conditions to improve performance when performing specific military tasks.

It is known that an increase in oxygen demand during physical activity is accompanied by the mobilization of all parts of the body's gas transport system. At the same time, the functionality of the respiratory, circulatory and blood systems determines the delivery of oxygen to tissues, the level of aerobic capacity and the overall physical performance of the body. Determining the functional reserves of individual links of the gas transportation system is an important prognostic criterion that allows us to identify the "weak" link that limits the delivery of oxygen during physical activity, and, accordingly, the level of maximum oxygen consumption. Due to methodological difficulties, it is quite difficult to assess the effectiveness of many elements of the gas transportation system, however, their close connection with each other expands the possibilities of mathematical modeling in assessing the functional state and ways to optimize oxygen transport systems against the background of various disturbing influences, including physical activity, hypoxic conditions etc.

All this suggests that in order to obtain information about the preparation process, it is necessary to process and systematize significant amounts of information. The basis of such systematization are mathematical models and their software implementation. Therefore, it is justified to choose a model for regulating the oxygen regimes of the body [18] to assess the level of aerobic capabilities of the body under conditions of maximum physical activity, identify and find ways to correct the "weak" links of the gas transport system for subsequent optimization of their functioning. The operating diagram of the model is shown in Fig. 3.

Note that during the application of this technique, software implementations were created that correspond to the current development of computer hardware and software. A review of these developments is contained in [19, 20], one of the latest developments is [21].

Work experience has formed a number of requirements that must be met at the modern level. General system requirements (Fig. 3).

Among the most accessible we can note:

1. A standalone desktop application for a specific operating system (for example, an executable file for Windows). Applications can be developed using programming languages such as C++, C# etc.
2. Desktop application based on Microsoft Access.
3. Cross-platform standalone application written in Java.
4. Web application.

A comparative analysis of these approaches is given in the table.

As a result of the analysis of existing capabilities, a web application was chosen, since the web application has a number of advantages from the user's point of view (Fig. 4).

Since the model has a simple structure it made sense to use an existing website building tool, which on the one hand should allow the creation of websites with relatively little programming effort, and on the other hand, it should allow extensive use of databases and relatively complex calculations. One of the best options turned out to be the OpenXava platform [22]. OpenXava is an open-source Low-Code Platform and a web framework for business application development. It offers a build and design tools that simplifies development and design of database application.

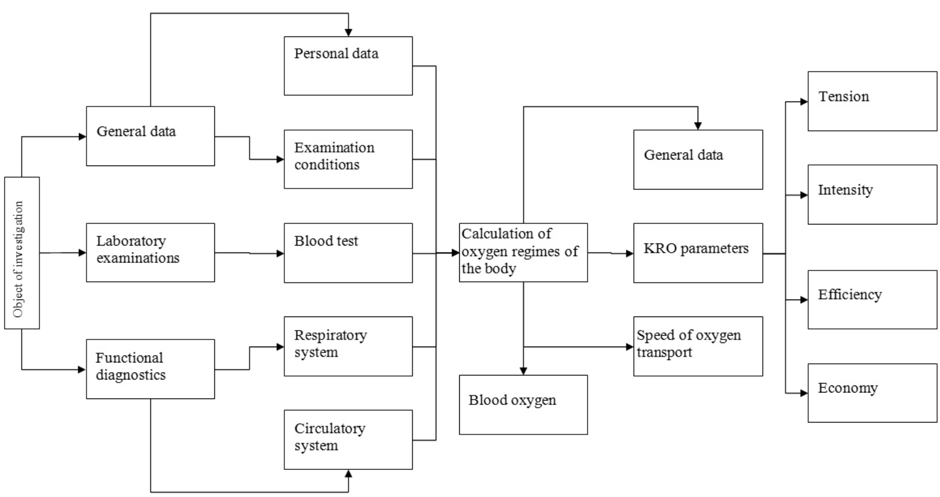

Fig. 3. Scheme of operation of the model for regulating oxygen regimes of the body

Table 2 Comparative analysis of possible approaches to developing an application for calculating the parameters of the body's oxygen regimes:

System type	Advantages	Disadvantages
Executable files	Developers can design the system as they wish. Developers can use existing libraries in their chosen programming language.	All parts of the interface need to be developed. You must install a database server or implement an embedded database. Depends on the platform (different executables for Windows, Linux, Mac).
Microsoft Access	The database for storing data is part of the application. It is relatively easy to develop forms and reports.	Requires installation of Microsoft Office with Access on the user's computer - quite expensive. Depends on the version of Microsoft Office. Windows only.
Java Desktop Application	Cross-platform system. Developers can design the system as they wish. Developers can use existing Java libraries.	Java must be installed on the user's computer. All parts of the interface need to be developed. You must install a database server or implement an embedded database.
Web application	Cross-platform system. Only a web browser is required. Multiple users can use the same data. There are many different website development platforms available.	The system must be installed on a remote web server.

The second reason for choosing this platform was the presence of convenient functions from a developer's point of view (Fig. 5).
Note also that OpenXava is based on the Java Persistence API (JPA), dependency injection for Java, and component validation standards. A developer familiar with these techniques can modify the behavior of the OpenXava system, but in most cases the standard OpenXava functions are sufficient to enable the use of fairly complex calculation algorithms. The current version of the Respiration model has the following tabs (entities): "Person" tab: permanent data of a person, such as full name, zip code, date of birth, height. Required fields such as Full Name. Date of birth etc. have thick borders. Age is calculated automatically based on date of birth and current date. Conditions tab: Experiment conditions such as atmospheric pressure and air temperature. Personal data tab: some personal parameters during the experiment, such as body weight and body temperature. On the "Results" tab, the user (operator) can select personal data and conditions corresponding to the experiment, as well as enter the measured respiratory, hemodynamic and blood data. After saving the initial data, the parameters of the respiratory system, blood circulation and oxygen regimes of the body are calculated.

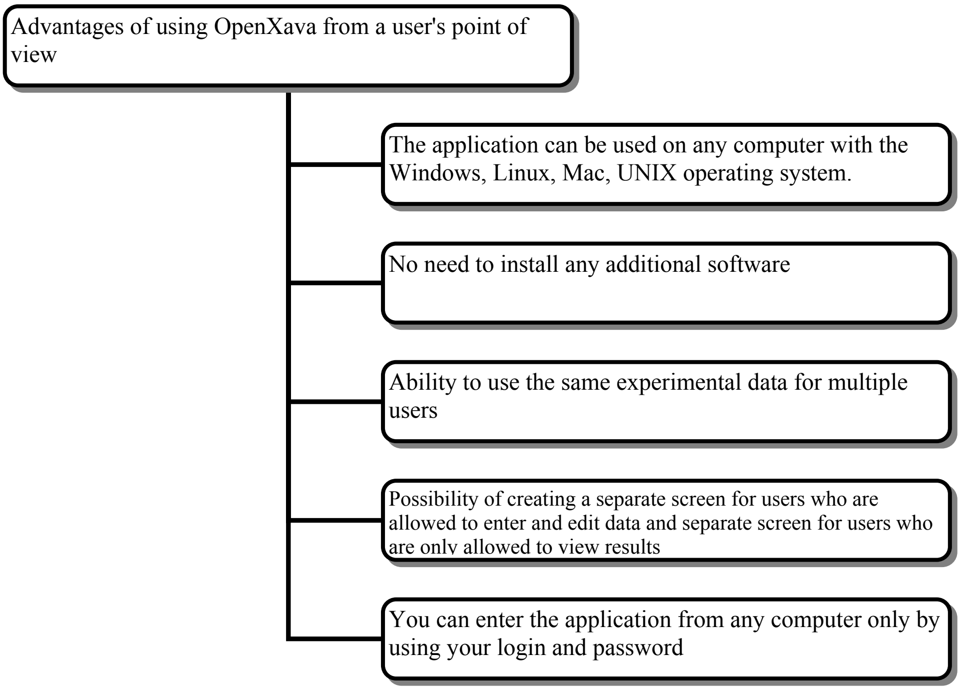

Fig. 4. Advantages of using a web application from the user's point of view

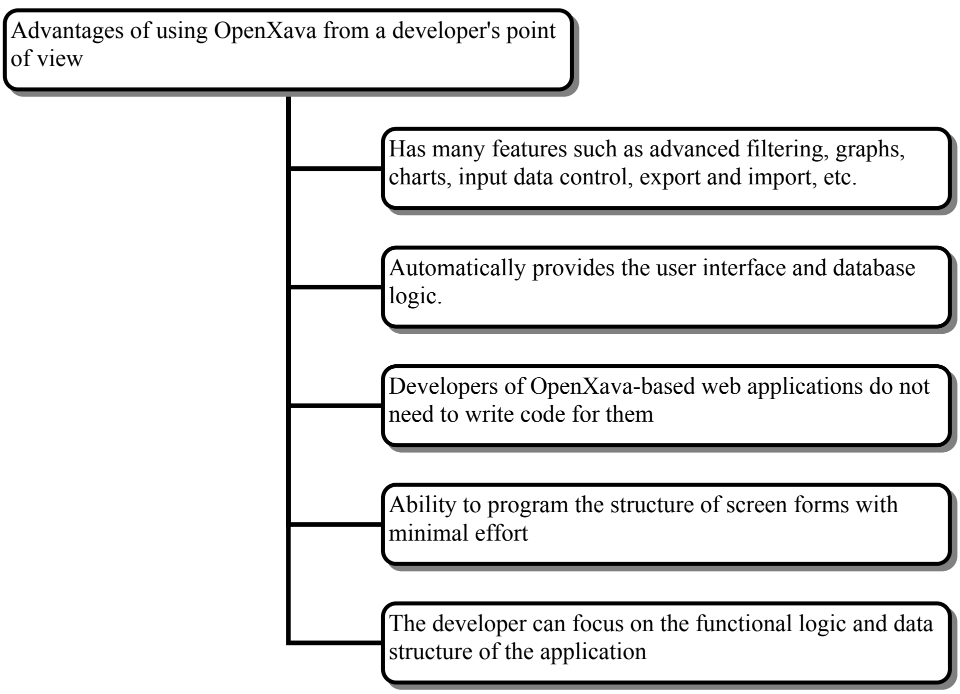

Fig. 5. Advantages of using OpenXava from a developer's point of view

CONCLUSION

The paper presents a web application for studying the oxygen regimes of the body, developed on the OpenXava platform. Compared to existing similar software, this development provides the user with a more convenient service; it is suitable not only for the Windows operating system, but also for Linux, Mac, UNIX, Android and does not require the installation of additional software. The user has the ability to import input data from files (for example, CSV or Excel), sort and filter source and calculated data by any criterion, export selected or filtered results to a file (for example, Excel file), present filtered source and calculated data on plots, charts or in the form of tables.

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ВЕБ-ЗАСТОСУНОК ДЛЯ КОНТРОЛЮ КИСНЕВИХ РЕЖИМІВ ОРГАНІЗМУ

Вступ. *В успішному виконанні військово-професійних завдань неабияку роль відіграє м'язова підготовленість військовослужбовців. Наразі на підготовку військовослужбовця виділяється 60 днів, отже актуальною є задача оптимізації цієї підготовки. Зазвичай силову витривалість можна ефективно покращити, поєднуючи силові, аеробні та спеціальні тренування з вантажем. Тому актуальною є задача об'єктивного контролю процесу підготовки. Ряд джерел наголошує на зв'язку травматизму військовослужбовців в умовах професійної діяльності з аеробною продуктивністю. Саме тому з метою контролю за підготовкою було вибрано модель регулювання кисневих режимів організму. Необхідність обробки значних масивів інформації обґрунтовує необхідність розробки зручних застосунків для цього.*

Мета роботи. *Розробити вебзастосунок для контролю процесу підготовки військовослужбовців на основі моделі керування кисневими режимами організму.*

Методи. *Методи математичного моделювання, методи програмування.*

Результати. *Розроблений вебзастосунок для моделювання кисневих режимів організму дає змогу здійснювати об'єктивний контроль швидкісно-силової підготовки військовослужбовців. Вебзастосунок розроблено на платформі OpenXava, що надає користувачу більш зручний сервіс, працює з операційними системами Windows, Linux, Mac, UNIX, Android і не потребує встановлення додаткового програмного забезпечення.*

Ключові слова: *математична модель регулювання кисневих режимів організму, професійна військова діяльність, швидкісно-силова підготовка військових.*