

The use of fitness trackers in the training process for increasing physical and functional abilities in athletes

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Abstract. The purpose of the study was to identify and justify the use of fitness trackers in the training process for increasing the level of physical and functional development in athletes of various ages. **Materials and methods:** athletes from aerobic sports (running and Nordic walking) aged from 18 to 65 years participated in the study (n = 136). The participants from the experimental group used a mobile device - a fitness tracker connected to a smartphone, which allowed to develop an individually-differentiated program for monitoring the speed and pulse of athletes. **Results:** the use of mobile technologies significantly improves the effectiveness of the training process. The results obtained prove a correlation between an increase in the endurance indicators of participants and an improvement in their functional status, especially at an older age. **Conclusion.** The use of fitness trackers with mandatory monitoring of the speed and pulse of an athlete engaged in physical activity contributes to the best result. The introduction of a system of self-monitoring of the cardiovascular system using mobile devices allowed eliminating cases of fatigue and injury in the experimental group.

Keywords - *fitness tracker, functional development, endurance, continuous monitoring, aerobic exercise*

I. INTRODUCTION

The modern mobile age, which is based on constantly updated technologies, requires a person to have qualities such as mobility, creativity and activity, the key characteristic of which is the physical fitness of a person [1, 2]. A harmonious combination of recreational, athletic and sports activities in the physical, spiritual, moral and creative development of a person [3, 4] undoubtedly contributes to the formation of such personal qualities [5]. A preliminary study of the impact of innovative technologies on the quality of physical education and sports showed existing contradictions between a rapidly changing life and the

training process, which cannot fully respond to social changes and satisfy the needs of a modern person [6, 7, 8].

The insufficiently developed methodological foundations for organizing the training process with the use of mobile devices allowed us to determine the purpose of the study - to identify and justify the use of fitness trackers in the training process for increasing the level of physical and functional fitness of participants of various ages.

Today, athletes of various ages are offered various mobile applications to individually increase the level of physical [9] and functional development [10, 11]. The developers are focused on meeting the needs of any user through differentiation of the proposed load [12]. Individual structural qualification characteristics of users are taken into account [13]. Not only for athletes, but also for their coaches or sports mentors, the use of digital diaries is a modern approach to physical education activities [14, 15].

Despite the possibility of using modern mobile devices, in particular fitness trackers, to promote physical activity [16], little is known about the use of modern trackers, applications for smartphones and heart rate monitors compared to other mobile devices [17]. In addition, a small number of studies are focused on the use of these new means of tracking physical activity among various population groups [18]. The analysis of domestic and foreign scientific and methodological literature has revealed particular relevance and novelty in the introduction of mobile devices in sports and athletic activities and allowed us to outline a strategy for experimental work on testing the implementation of the fitness tracker in aerobic physical activity: running and Nordic walking.

II. MATERIALS AND METHODS

Participants. The study was performed on the premises of the Municipal Autonomous Institution "Progress" (Glazov, Udmurt Republic). Athletes from aerobic sports (running and Nordic walking) aged from 18 to 65 years participated in the study ($n = 136$). Respondents were divided by age categories according to the levels of the All-Russian physical education and sports complex "Ready for Labour and Defence" (from VI to X stages) regardless of gender. Each group of participants was divided into two equal focus groups: experimental and control. During the experiment, all subjects underwent independent sports training according to the training program with methodological recommendations for improving the physical and functional parameters of the body and matching the "Ready for Labour and Defence" standards: running (2000/3000 m) and nordic walking (3000 m). The EG participants used a mobile device and a fitness tracker connected to a smartphone in their independent training process.

Materials. The theoretical and methodological materials used in this study are based on the mobile approach, the implementation of which provides a higher quality of the training process, in particular in aerobic types of physical activity. The solution to research problems was provided by a set of mutually complementary theoretical methods for the analysis of domestic and foreign pedagogical theory, practice and experience in the field of sports and recreation activities of people of different ages; general scientific methods such as classification, modeling, comparison and generalization. Mathematical-statistical data processing was performed using Chi-square (X^2) at $p < 0.05$. Monitoring the level of endurance was carried out by the tests from the All-Russian physical education and sports complex "Ready for Labour and Defence": running 2000/3000 meters for VI-IX age categories and nordic walking (3000 meters) for IX-X age categories. The performance of the tests was ranked from low to high as follows: bronze, silver, gold.

To determine the health status, the Pirogova's method was used, which allows for a rapid assessment of physical fitness with the help of the indicator of the circulatory system calculated according to the formula: $X = (700 - 3 * HR - 2.5 * APd + (APs - APd) / 3 - 2.7 * A + 0.28 * W) / (350 - 2.7 * A + 0.21 * G)$, HR - heart rate, G - body growth, cm; W - body weight, kg; A - age, full years, APs - systolic pressure, APd - diastolic pressure. High level: $X \geq 0.8$; average level: $0.8 > X > 0.4$; low level: $X \leq 0.4$. To determine the level of functional abilities of the body, the method of N.M. Amosova was used. Participants were divided based on the following formula: $X = 0.011 * HR + 0.014 * APs + 0.008 * APd + 0.014 * A + 0.009 * W - (0.009 * G + 0.27)$. High level: $X \leq 2.3$; average level: $2.3 < X < 3.1$; low level: $X \geq 3.1$. These methods are based on a quantitative assessment of health [1], which is determined by the fitness of the structural elements of the body [18, 19].

Procedure. The organization of the experimental work was focused on targeted stimulation of students of various ages to independent physical education activities through individualization and differentiation of the use of mobile devices. The research was conducted by means of providing mobile technologies to each athlete of the experimental group stimulating them for physical self-improvement using smartphones [20]. When introducing mobile content in the

training process, it was especially important that the participants would use mobile technologies only on a rational and methodically correct basis [21].

Before the experiment, the participants of both groups had a level of physical development (endurance) that corresponded to the bronze standard (Xb) in the "Ready for Labour and Defence" test and was equal to $Xb^*(1.18 \pm 0.08)$ for all tests in running and nordic walking. Mathematical and statistical processing revealed no significance in differences at $p > 0.05$, both in terms of endurance and in the functional development of respondents. On average, the indicators for the groups were below the average level.

For 6 months, respondents participated in an independent training process under the guidance of a trainer at least 3 times a week. Each 60-minute sports lesson consisted of a general and aerobic warm-up, overcoming the track at the pace recommended by the trainer, and the dosage appropriate for the age, as well as special gymnastic exercises in the final part of the lesson. After the first half of the experiment, participants were offered another lesson on Saturday or Sunday. The training process in the experimental group was accompanied by monitoring their performance with the help of a fitness tracker connected to a smartphone. During running or nordic walking, the fitness tracker was located on the athlete's hand just above the thinnest part of the wrist. It was not allowed to wear the fitness tracker in a tightened or too weakened form, as this adversely affected the effectiveness of measuring heart rate.

It should be noted that the measurement of the athlete's heart rate during exercise was carried out on the basis of the optical method. There are three basic methods for measuring heart rate: mechanical, electrical, and optical. The first is used in conventional blood pressure monitors, recording the frequency of pressure drops caused by the work of the heart. The electrical method is possible due to the fact that in the process of contraction, the heart muscles produce microcurrents. It is most often used in equipment for electrocardiography with heart and chest sensors for measuring heart rate. The disadvantage of these methods is the need for a tight contact between the sensor and the body. In the first case, the sensor should be pressed to the skin, in the second - be as close to the heart as possible [4]. Therefore, for equipment like a fitness tracker or smart watch, both options are not suitable [22]. A fitness tracker, tightened on the wrist, can impair blood flow, while removing electrical impulses requires the use of an external sensor. The indicated drawbacks are deprived of an optical heart rate monitor, which only needs to have contact with the skin, and not necessarily tight. Located on the bottom of the watch or tracker, it does not interfere with the user, does not affect blood flow, consumes little energy and transmits data with sufficient accuracy. Therefore, it is optical sensors that are now used most widely [16].

Using a smartphone connected to a fitness tracker, we analyzed the speed of movement (meters per minute) at a distance and heart rate during movement [4]. The optimal training loads by weeks (6 months), which were proposed to the participants of the experimental group, are reflected in Table 1:

TABLE I. INDIVIDUALLY-DIFFERENTIATED WEEKLY PROGRAM OF SPORTS TRAINING

Weeks	Number of training sessions	Heart rate / Sports training zone	Optimum speed (m/min)
1		Input testing	
2-4	8-10	55-65% of max (fat burning zone)	Y / Xb * (1.1±0.05)
5-7	8-10	55-65% of max (fat burning zone)	Y / Xb * (0.97±0.03)
8-10	9-11	65-75% of max (aerobic zone)	Y / Xb * (0.93±0.04)
11-13	9-11	65-75% of max (aerobic zone)	Y / Xs * (1.12±0.05)
14-16	9-11	65-75% of max (aerobic zone)	Y / Xs * (1.1±0.03)
17-19	10-12	75-85% of max (anaerobic-prelimit zone)	Y / Xs * (0.99±0.1)
20-22	10-12	75-85% of max (anaerobic-prelimit zone)	Y / Xg * (1.12±0.05)
23-25	10-12	85-95% of max (limit zone)	Y / Xg * (1.07±0.07)
26	3	Control testing	

*Heart rate (max): for men - "210 - A/2 - (0.11*W) + 4"; for women - "210-A/2- (0.11*W)"; Xb - result for the bronze medal (minutes), Xs - result for silver (minutes), Xg - result for the gold medal (minutes), Y - distance corresponding to the "Ready for Labour and Defence" (meters)

Based on the content of Table 1, for 6 months, participants in the experimental group performed running or nordic walking exercises. On a mobile device, the speed of movement was determined and the maximum (individually could set an additional minimum) allowable athlete's heart rate corresponding to the training week. If the athlete's heart rate was higher than the permissible values, a vibrating or audible signal was used, and the participant decreased the speed along the distance.

However, the athlete's speed should have corresponded to acceptable indicators of the optimal speed of movement along the distance stated in the individually-differentiated program. If the participant could not achieve the optimal speed in the corresponding pulse range during certain training sessions, he remained in the same training zone. By the end of the study, of all the participants in the experimental group (n=68), only 23 reached the limit zone and 31 the anaerobic or prelimit zone.

III. RESULTS AND DISCUSSIONS

At the end of the experiment, control testing was performed, both in terms of physical and functional development of participants.

As shown in Fig. 1, the number of participants in the EG and CG who received the bronze, silver and gold medals in the running test was significantly different $p < 0.05$:

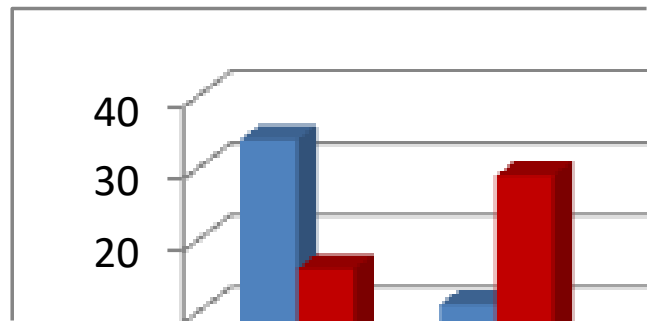


Fig. 1. Results of the running test in the experimental and control groups

The obtained results prove the effectiveness of the training process. It should be noted that there was a significant increase in the number of participants in the experimental group (n=22) compared to the control group (n=5) that received the gold medal in the "Ready for Labour and Defence" test. As well as there was an increase in the number of participants in the experimental group (n=29) compared to the control group (n=11) who achieved the silver medal.

The results obtained prove the effectiveness of the training process aimed at increasing the physical development of participants. It should be noted that only one participant in the experimental group was not able to meet the minimum standard for the medal in the "Ready for Labour and Defence" test, compared to the control group. This group included a significant number of athletes (n=18) who did not match the standards of the test.

As shown in Fig. 2-3, the number of participants in the EG and CG that corresponds to the high, medium, and low levels of functional development is significantly different at $p < 0.05$.

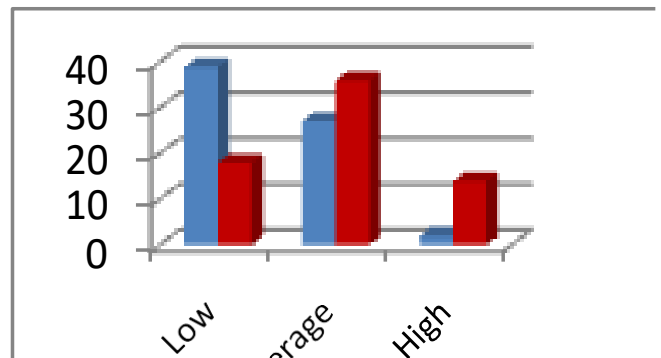


Fig. 2. Results of experimental study according to the method of E.A. Pirogova

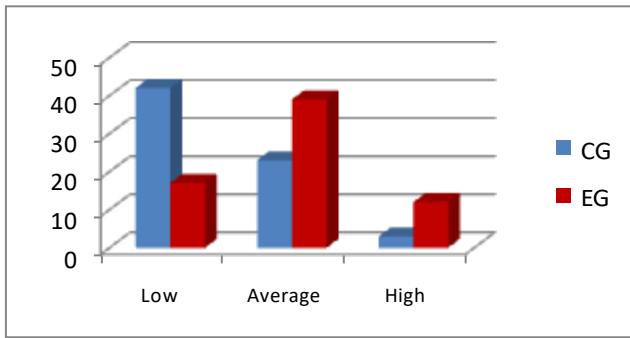


Fig. 3. Results of experimental study according to the method of N.M. Amosova

The results obtained prove a positive effect not only in terms of physical development, but also in the functional abilities of the participants. The statistics obtained indicate a correlation between an increase in the endurance indicators of respondents and their functional abilities. This, in turn, is especially important for increasing motivation for training in older athletes.

To confirm the positive result and identify the age group in which the experiment had a more reliable effect, a further comparative analysis was carried out. This monitoring was implemented by ranking indicators in the experimental group according to intensity levels. In Fig. 4. Comparative results are shown in the percentage of experiment participants (n=68) who completed the training cycle in the limiting zone (n=23) - EG1p, the anaerobic or prelimit zone (n=31) - EG2an, the aerobic zone (n= 4) - EG3a levels of functional development according to the methods of N.M. Amosova and E.A. Pirogova. Since the results for both methods were statistically equal, we show only one general Fig:

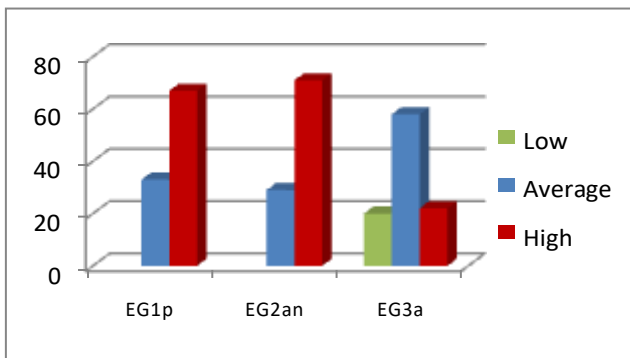


Fig. 4. Results of the correlation analysis of EG indicators by methods of functional development (%)

As a result, it was found that among the participants who completed the training cycle in the aerobic zone, indicators corresponding to a low health level were recorded (n=20). The number of subjects with a high and medium level of functional development was statistically equal ($p>0.05$) among participants who completed the training cycle in the prelimit or anaerobic and limiting zones (n=100). A more detailed analysis of athletes revealed the following results for the participants aged 50-59 years old at stage IX (n=19) (Fig. 5):

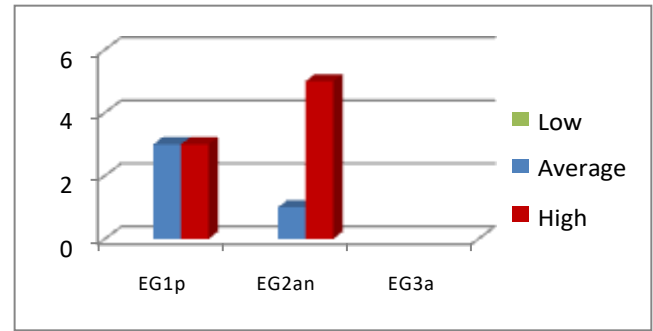


Fig. 5. Results of the correlation analysis of EG indicators in participants aged 50-59 years according to the methods of functional development

Athletes aged 50-59 years who completed the experiment in the aerobic zone were not recorded (n=0). However, among the athletes who completed the training cycle in the prelimit or anaerobic zone (n=5) there were significantly more people with a high level of functional development ($p<0.05$), compared with participants in the limiting zone (n=3). Analysis of athletes (n=4) of the older X group was not possible. Since for a reliable analysis, a greater number of respondents is needed. This determined the strategy for further research to analyze the effectiveness of the author's program for the people of retirement age.

Discussion. The results of this study are consistent with the results of other studies on the introduction of mobile technology into the training process [15, 21]. The studies experimentally prove the positive aspects of using various mobile technologies [13]. For example, mobile digital diaries, which are used to monitor the state of health and physical fitness [14, 15]. Namely, the proposed applications motivate those involved to adopt a healthy and active lifestyle [23]. Our individually-differentiated program can also serve as an incentive for physical education to improve individual physical fitness through awareness of the need for daily exercise.

Many researchers prove that users of digital applications are more likely to actively participate in independent physical activities [10] compared with those who do not use such applications for self-control [11].

It is interesting to note that the most important function for the respondent is to count the steps that can be achieved using a simple device, such as a pedometer [24]. This may be due to the fact that the number of steps is a reliable result that is easy to comprehend, measure and interpret [25, 26]. However, as the results of our study show, the most popular function is the measurement of heart rate, which is increasingly found in modern fitness trackers when synchronizing with mobile devices.

Some studies experimentally prove that most respondents indicate that they would like to receive notifications about their physical activity several times a day [27]. However, the current study proved that only continuous monitoring of the athlete's body can have a positive effect on the athlete's performance. Users are accustomed to customizing technology and software in accordance with their preferences and needs [20]. Therefore, the more continuous settings we can enable, the more users will be satisfied. The greater the likelihood that they will be motivated to perform physical exercises [23]. Therefore, an understanding of user preferences for various software products for fitness activity

trackers according to age categories is vital for the successful use of physical activity and health monitoring devices.

Researchers and experts in the field of physical education and sports, considering the possibility of using trackers to facilitate self-monitoring of physical activity, should note that the technology and cost of trackers are not significant barriers to their use in general [16]. The most common causes of reluctance to use an activity tracker are beliefs that trackers are not effective and that they are not useful for increasing physical activity [22]. However, our study shows that athletes of any age who are focused on increasing their physical activity can achieve this when using mobile devices.

A theoretical analysis of studies on the informatization of physical education and sports proves that the regular use of these technologies increases the effectiveness of the training process in various sports and physical activity of people of different ages [1, 19]. The use of fashionable gadgets significantly improves the effectiveness of the training process [3, 10]. However, the results obtained in our study showed that it was the use of a fitness tracker with the function of continuous monitoring and heart rate control that contributes to a high result. Nevertheless, an improvement in physical development, as shown by the experiment, does not always significantly correlate with an increase in the level of functional development or health, especially at an older age.

IV. CONCLUSIONS

The results of the current study show that the participants expressed a high level of interest in using fitness trackers, and therefore, this can be a promising method for attracting people to self-control in terms of their physical activity. The monitoring of the cardiovascular system of middle-aged and elderly people with mobile devices allowed us to exclude cases of overwork and injury in the experimental group.

The availability and use of mobile technology, in particular fitness trackers, is rapidly being updated. Consequently, the data collected and systematized in the study will continue to evolve and improve. Further research is needed to test the effectiveness of the fitness tracker. Such results will help specialists in physical education and sports, as well as researchers who develop mobile applications in this direction, in choosing new methods and approaches to motivating the population to physical activity.

The results show that older people more often use the function of measuring steps and self-monitoring of the cardiovascular system, while modern trackers with nutrition features and various sports ratings often attract younger participants. Since satisfying the needs of users is important for enhancing the use of fitness trackers, these preferences should be considered when developing further research in this direction. Further research on the use of mobile devices in the training process will be aimed at studying their influence on the effectiveness of athletes depending on their gender and the types of physical activity, such as cross-country skiing, cycling, etc.

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