UDC 613.7:796.071.2:796.015:612.76:311.212 https://doi.org/10.26641/2307-0404.2025.2.333679

RESILIENCE OF INDIVIDUAL HEALTH AND ENDOGENOUS RESPONSE TO DETERMINANTS OF MOTOR ACTIVITY OF ATHLETES

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Цитування: Медичні перспективи. 2025. Т. 30, № 2. С. 190-203
Cited: Medicni perspektivi. 2025;30(2):190-203

Key words: *health resilience, endogenous response, motor activity of athletes*
Ключові слова: *резильєнтність здоров'я, ендогенна відповідь, рухова активність спортсменів*

Abstract. Resilience of individual health and endogenous response to determinants of motor activity of athletes. Sirenko P.O., Storozhenko I.P., Sirenko R.R., Yuzyk O.P., Kindrat V.K., Lietuviete D., Kolesnyk T.V. *The issue of specialized multicomponent studies of defining the functional state of the organism under the influence of personalized factors of external influence in sport is not sufficiently studied in the scientific and methodological literature. It needs to be expanded and supplemented. The aim of the study was to determine the resilience of an individual's health and the components of the endogenous response to the determinants of athlets's motor activity. The study involved 15 experienced football players, whose average age was 25.47±4.66 years.To achieve this goal, based on the analysis of scientific and methodological literature and the questionnaire, we identified the factors of exogenous influence and the main determinants of motor activity of athletes. An additional specialized questionnaire was conducted to assess the personalized general state of health. According to the previous diagnostic data and on the basis of empirical components, a programme for the development of certain motor qualities (general, power endurance) as a specialized training was developed, which was coordinated with the training process of athletes. Before the beginning of the formed programme*

the testing of the background assessment of development of aerobic functional capabilities was carried out. In the context of the research the programme with the use of certain determinants of motor activity was implemented. We repeatedly tested the development of aerobic capabilities, determined the resilience of an individual's health and the impact of the research block of exogenous agents on the state of the cardiovascular and muscular systems. We also used a repeated questionnaire to assess the general state of health and health resilience of the individual. We determined the conditions for the implementation and effectiveness of the use of determinants of motor activity as exogenous factors of influence on the health resilience of an individual. Specialized questionnaires and protocols have been created to determine the priority personalized factors of exogenous influence and the operational state of the organism. Based on the data obtained, a programme for the development of motor skills was developed and scientifically and methodically regulated. A systematic assessment of the functional state of athlets on the basis of test models and statistical processing unit was carried out. Defining determinants of motor activity of athletes, resilience of health of an individual and specialized methods of assessment of influence of exogenous factors requires statistically confirmed efficiency of the offered methods in the structure of experimental and research check of their use. The methodology for applying an individual programme for the development of functional capabilities of the motor systems of the body of athletes has been established and substantiated. The effectiveness of the influence of exogenous means on the state of functional systems of the organism in the direction of general and power endurance is statistically substantiated. The positive influence on the general state of health (according to the questionnaire, monitoring of heart rate and intensity of movement, analysis of graphic images built on the obtained indicators) is established.

Реферат. Резильєнтність здоров'я індивідуума та ендогенна відповідь на детермінанти рухової активності спортсменів. Сіренко П.О., Стороженко І.П., Сіренко Р.Р., Юзик О.П., Кіндрат В.К., Ліствуєте Д., Колесник Т.В. *Питання спеціалізованих багатокомпонентних досліджень визначення функціонального стану організму під впливом персоналізованих чинників зовнішнього впливу в спорті в науковій та методичній літературі вивчене не достатньо, тож потребує розширення та доповнення. Метою дослідження було визначення резильєнтності здоров'я індивідуума та складових ендогенної відповіді на детермінанти рухової активності спортсменів. У дослідженні брали участь 15 досвідчених футболістів, середній вік яких був 25,47±4,66 року. Для виконання поставленої мети на підставі аналізу науково-методичної літератури та проведеного анкетування нами були визначені фактори екзогенного впливу та основні детермінанти рухової активності спортсменів. Було проведене додаткове спеціалізоване анкетування стосовно персоналізованої оцінки загального стану здоров'я. За даними попередніх діагностичних пунктів та на підставі емпіричних складових розробляли програму розвитку визначених рухових якостей (загальної, силової витривалості) в якості спеціалізованого тренування, що було узгоджено з навчально-тренувальним процесом спортсменів. Перед початком сформованої програми проводили тестування фонової оцінки розвитку аеробних функціональних можливостей. У контексті дослідження впроваджували програму із застосуванням визначених детермінант рухової активності. Проводили повторне тестування розвитку аеробних можливостей, визначали резильєнтність здоров'я індивідуума та вплив на стан серцево-судинної та м'язової систем дослідницького блоку засобів екзогенного впливу. Також нами було застосоване повторне анкетування щодо загального стану та резильєнтності здоров'я індивідуума. Нами було визначено умови впровадження та ефективності застосування детермінантів рухової активності як екзогенних факторів впливу на резильєнтність здоров'я індивідуума. Створені спеціалізовані анкети, протоколи для визначення пріоритетних персоналізованих чинників екзогенного впливу та оперативного стану організму. На підставі отриманих даних розроблена та науково – методично регламентована програма розвитку рухових якостей. Проведено системне оцінювання функціонального стану спортсменів на підставі моделей тестів та блоку статистичної обробки. Визначення детермінантів рухової активності спортсменів, резильєнтності здоров'я індивідуума та спеціалізованих методик оцінювання впливу екзогенних факторів потребує статистично підтвердженої ефективності запропонованих методик у структурі експериментально-дослідної перевірки їх застосування. Встановлено та обґрунтовано методику застосування індивідуальної програми розвитку функціональних можливостей рухових систем організму спортсменів. Статистично обґрунтовано ефективність впливу на стан функціональних систем організму екзогенних засобів у напрямку загальної та силової витривалості. Встановлений позитивний вплив на загальний стан організму (за даними анкетування, моніторингу серцевого ритму та інтенсивності руху, аналізу побудованих за отриманими показниками графічних зображень).*

Increasing the intensity of external influence on the body of modern athletes of game sports (in the case of our study – professional football) forces us to face the problem of urgent and long-term definition of the main determinants of motor activity [1]. Determinants that regulate the response of humoral and morphological systems of the body to the endogenous component: individual determinants of motor activity, namely the definition of the paradigm of physical activity and the resilience of the individual's health [2].

Of their considerable number, we will single out several that generalize health, physical performance and load structure under certain conditions [3]. A modern athlete, as a result of the development of remote visual technologies, tries to apply certain physical components of influence on his body without sufficient rationalization in their construction.

The organization of the training process is not always based on substantiated physiological indicators [4, 5]. Due to the limitation of motor activity data and the level of its organization, the percentage of athletes with insufficiently developed specialized motor endurance qualities and the level of development of general working capacity is increasing [4]. These factors not only reduce the quality of life and increase injury rate, but also worsen the quality of everyday life, the effectiveness of training and competitive actions. It is also relevant that today there is insufficient study of the influence of the main determinants of motor activity and resilience of the individual's health [6]. Theoretical, methodological and experimental substantiation of a unified structure of classes for people with an active lifestyle and athletes, using the capabilities of the most useful types of motor activity, is a priority issue for the formation of general components of improving the quality of life [7, 8]. The use of a conglomerate of specialized exercises and morphological studies allows overcoming the stereotypes of a limited set of diagnostic methods not only by combining pedagogical and analytical directions, but also by an individual-personal approach to improving the level of health resilience [9, 10]. Analysis of scientific data on the determinants of athletes' motor activity and their impact on the resilience of an individual's health made it possible to identify the components of the problem in the form of the following contradictions:

- at the scientific-theoretical level: between the need for in-depth knowledge of the use of exogenous means of influence on the functional systems of the body and the limited number of scientific and methodological works of theoretical substantiation of their components;
- at the socio-pedagogical level: between the social needs of implementing the latest methods;
- at the practical-methodical level: between the context of implementing practical methods in the field of sports and the limited amount of material for training specialists in specialized areas with the appropriate level of preparedness.

Therefore, the insufficient study of the impact of determinants of motor activity on the health of an individual became the basis for choosing the direction of research.

The purpose of the study is to define the determinants of motor activity of athletes and the resilience of the individual's health under the influence of exogenous factors.

MATERIALS AND METHODS OF RESEARCH

Verification of the use of determinants of motor activity in the training process of athletes and control of the effectiveness of the impact of the proposed methods on the health of an individual were carried out by conducting a research block, which included the ascertaining and forming stages. Based on the factors highlighted in the previous sections, we determine the individual determinants of motor activity, which are responsible for the physical and functional component. 15 experienced football players were involved in the studies. The average age of the participants was 25.47±4.66 years.

All athletes received written consent to conduct and publish the results of the study. The study was conducted in accordance with the principles of bioethics set forth in the Declaration of Helsinki "Ethical principles of medical research involving humans" and the "Universal declaration on bioethics and human rights (UNESCO)". Protocol of the Commission on Ethics and Academic Integrity No. 8 of the P.L. Shupyk National University of Health Care of Ukraine

1. The ascertaining stage of the pedagogical experiment provided for the implementation of the following theoretical and practical tasks:

- theoretical tasks: to develop a methodology for introducing individual determinants of motor activity of athletes into the educational and training process; to substantiate the practical application of an individual program for the development of the functional capabilities of the motor systems of the athletes' body; to systematize the data of the first block of the staged questionnaire on the assessment of the health of the individual and the staged functional testing of aerobic performance;
- practical tasks: to develop a questionnaire and conduct a survey on the topic of a personalized priority sequence of the importance of specialized factors of the determinants of athletes' motor activity for the health of an individual (based on the analysis of scientific and methodological literature and the data obtained, determine the main directions of implementing the experimental program); to develop a questionnaire and conduct the first block of a staged survey on assessing the health of an individual; to create a combined program for the development of specialized motor qualities and its coordination with the structure of the educational and training process of experienced football players (FCI Levadia, Tallinn, Estonia); to conduct the first block of staged functional testing (according to the defined and recommended components); to implement and apply exercises of a certain orientation.

2. The formative stage of the study was aimed at solving the following theoretical and practical tasks:

- theoretical tasks: systematization of data from the second block of a staged survey on assessing the health of an individual and staged functional testing of aerobic performance; statistical processing; generalization of the obtained data (formulation of conclusions regarding the influence of determinants

of motor activity on the resilience of the individual's health);

- practical tasks: conducting the second block of staged functional testing; conducting the second block of staged questionnaires on assessing the individual's health.

The implementation of the proposed comprehensive program was implemented over 4 months from 12.2023 to 03.2024. From 12.2023-02.2024 – conducting an experimental block of research. From 03.2024 – processing and systematization of the obtained data.

At the beginning of the ascertaining stage of the study, we conducted a general survey using a created specialized questionnaire with the corresponding survey (Survey Questionnaire No. 1 (Appendix a)). The task was to determine the points regarding the most important component of the physical and functional determinants of motor activity and their impact on the individual's health (in percentages). Nought (0) was taken to mean the absence of importance of the factor of determinants of motor activity, and 100 was the most important component.

Questionnaire No. 1 (Appendix a)

Priority sequence of importance of specialized factors of determinants of motor activity of athletes for the health of an individual in %	
1. Full name	
2. Age	
3. Weight	
4. Height	
5. Resting heart rate	
Estimate the importance in percentage of importance for the health of an individual of the following specialized factors of determinants of motor activity:	
Block 1. Physiological	
6. General level of physical fitness	
7. General endurance	
8. Speed endurance	
9. Power endurance	
10. Strength	
11. Flexibility	
Block 2. Medical	
12. General health	
13. Injury prevention	
14. Rehabilitation after injuries	
Block 3. Psychological	
15. Motivation	
16. Resilience	
17. Self-confidence	
18. Emotional state	
Block 4. Social	
19. Family support	
20. Coaches and team	
21. Social recognition	
Block 5. Technological	
22. Innovations in training equipment	
23. Digital technologies	
24. Data analytics	

By signing this Questionnaire, I consent to the processing of personal data.

Having determined the contextual component of the main factors of the determinants of motor activity, the question of a system for assessing the resilience of an individual's health arose, namely, the internal perception of the state of the organism, the coordinated regulation of all organs and systems. We developed a questionnaire (Survey Questionnaire No. 1 (Appendix b)) for personalized health assessment. Its use involved the implementation of a survey before the start of the experiment and at its completion.

Based on the systematized data of the initial information base, a scientific and methodological basis was formed, pedagogical methods were developed for optimizing the determinant factors of the motor activity of athletes and analyzing their impact on the health of the individual. Optimal conditions are created for im-

proving health and general physical fitness and specialized development of certain determinants of motor activity in the organization of motor activity of professional football players at the beginning of the annual periodization [11]. Separately identified by us, of the total number of determinants of motor activity, were those that affect the development of general and strength endurance. We have developed and implemented a specialized methodological program in the structure of the involving and basic mesocycle of the general preparatory stage of the preparatory period, divided into separate blocks lasting 14 days for 3 months. It is the basis for the consistent formation of specialized functional components (starting with a small (20-40%), gradually moving to the limits of 60-70% intensity). The upper limit is 60-70% since this regulation is the average physiological limitation of the zone of development of aerobic qualities. In the context of the development of strength endurance on mechanical simulators, we will focus on the generalized effect on the muscles of the lower limbs in the structure of circuit training with an asymmetric (on the antagonist muscles) load distribution. In percentages, we considered the total intensity of the load during training. If 0% is rest, 100% is a game. The optimal conditions for the development of strength and speed endurance are the component of a certain "underrecovery". The content of the microcycle limits the phase of full recovery. We regulate the context of loads by intervals of specialized classes every two days on the third in an alternating sequence: combined general and special endurance training with training on mechanical simulators. Methodologically, the development of strength endurance involves 6-7 sets and 12-15 repetitions per individual muscle group with a small rest interval; the development of general endurance involves performing movements within the aerobic heart rate zone (HR).

The organization of the experimental group's activities included the following areas:

- training on mechanical simulators lasting 60-80 minutes was carried out 2 times a week in the mode of involving the main muscle groups of the lower limbs. By the method of strictly regulated exercise, in a circular manner. The total number of circles was 5-6, the number of repetitions was regulated by a time interval of 30 seconds (Fig. 1).

- aerobic training (combined or specialized) was carried out 2 times a week at the specified load intensity with differentiated regulation of exercise time (Fig. 1).

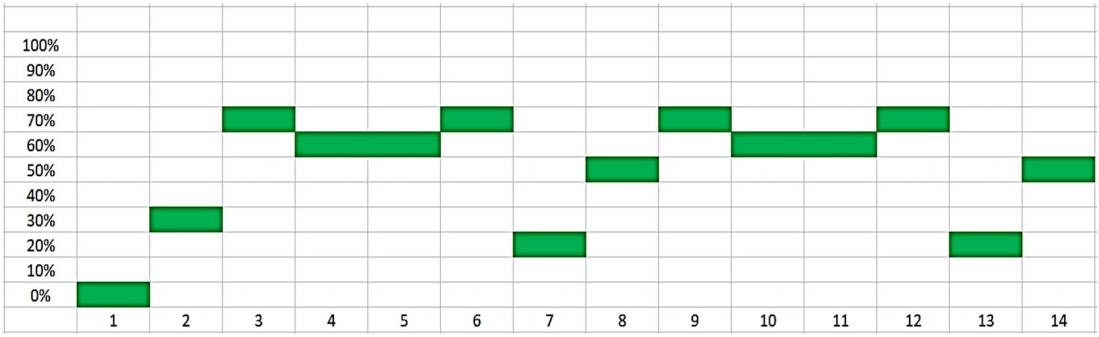

Fig. 1. A fragment of the program in the structure of the involving and basic mesocycle of the general preparatory stage of the preparatory period (vertical axis - load intensity, horizontal axis - days of the week)

In addition to the factors that were determined by means of the questionnaire, an important component is the component of assessing performance in the general endurance zone. At the beginning of the experiment and at its completion, we introduced a test for assessing the aerobic capabilities of the body "Yo-Yo intermitted recovery level 2" [7]. The ratio of indicators and the obtained statistical data was determined. We examined the dependence of the indicators of the cardiovascular system and the intensity of movement at the first and second stages of the study. It was presented in the form of a graphic image and tables.

The results of the questionnaire and the quantitative characteristic of Yo-Yo testing were subjected to statistical processing. The initial data of the Yo-Yo test are the dependence of heart rate on the intensity of movement (running speed). However, as a quantitative characteristic for statistical comparison of results, we used the integral HR – the integral of the dependence of heart rate on the intensity of athletes' movement and the average heart rate values within the Yo-Yo test.

Statistical processing of the study results was carried out using standard free open source statistical software packages (GNU PSPP (https://www.gnu.org/software/-pspp/), GNU Octave (https://octave.org/), and Fityk (https://fityk.nieto.pl/). The statistical significance level was $p \leq 0.05$.

The homogeneity of the sample was ensured by approximately the same level of physical fitness, gender, and age of the study participants. The training group included 15 experienced male football players, aged 20.8 to 30.1 years.

The homogeneity of the sample was checked by the modified Z-score. The modified Z-score is a reliable nonparametric method for detecting outliers in small samples, as it is based on the median and the median absolute deviation (MAD), which provides robustness to extreme values and does not require normality of the distribution [12]. This is important, since very often the distribution quantitative characteristics of a social group differ from a normal distribution. The modified Z-score can be used for samples from n=5, but it is optimal to use it for n≥10, when the median and MAD are more stable. This corresponds to the sample being analyzed.

To compare quantitative indicators, we used the Wilcoxon paired t-test [13] and the parametric t-test. The Wilcoxon test is a reliable nonparametric method for comparing two dependent samples when the normality of the distribution cannot be guaranteed. Since the same group of athletes is tested before and after the training process, the samples are dependent. In this case, instead of the Mann–Whitney test [14], the Wilcoxon test is usually used. The use of the parametric t-test requires additional testing of the hypothesis of normal distribution and its acceptance.

Therefore, we checked the subordination of the obtained Yo-Yo-testing data to the normal distribution law using the Shapiro-Wilk agreement criterion [15]. The test The Shapiro-Wilk test is one of the most reliable methods for testing the normality of distribution for small sample sizes. Its high sensitivity allows for effective detection of deviations from normal distribution even with limited data. As will be shown, all random variables in the Yo-Yo test were found to be normally distributed.

The confirmation of the hypothesis of a normal distribution makes it possible to use parametric methods together with nonparametric ones, which increases the reliability of our conclusions. For a sample of 15, which has a normal distribution, the use of parametric statistical methods is justified, since these methods assume the normality of the data for the correct estimation of parameters. Provided that the assumption of a normal distribution is observed, parametric methods provide higher statistical power compared to nonparametric analogues, which is especially important with a small sample size [16].

So, we checked the equality of medians using the Wilcoxon test and, taking into account the confirmation of the hypothesis of a normal distribution of the quantitative characteristic of the Yo-Yo test, the equality of mean values using the t-test.

RESULTS AND DISCUSSION

The main resulting component of the study was to determine the conditions for the application and effectiveness of the application of determinants of motor activity as exogenous factors of influence on the resilience of the individual's health.

At the beginning of the study, we conducted a general survey using a questionnaire form of the priority sequence of importance of specialized factors of determinants of motor activity of athletes for the health of the individual in % (from 0 to 100), (Survey questionnaire No. 1 (Appendix a)). The points were determined regarding the most important component of physical and functional determinants of motor activity of their influence on the health of the individual. We selected the first 2 ranked factors on the basis of which we formed the resulting base. Where 0 is the lack of importance of the determinants of motor activity, and 100 is the most important component. Out of 15 respondents, the highest percentage received items 6, 7, 9 of block 1 regarding physiological determinants (Table 1). Item 6, regarding the general level of physical fitness – 95%; item 7, regarding general endurance – 85%; item 9, regarding strength endurance – 78%. Also, item 12, block 2 regarding medical determinants received 93%.

Table 1

Results of 15 subjects after the survey based on questionnaire No. 1 (Appendix a)

Block 1. Physiological
6. General level of physical fitness 95%
7. General endurance 85%
8. Speed endurance 71%
9. Power endurance 78%
10. Strength 67%
11. Flexibility 51%
Block 2. Medical
12. General health 94%
13. Injury prevention 72%
14. Rehabilitation after injuries 65%
Block 3. Psychological
15. Motivation 54%
16. Stress resistance 32%
17. Self-confidence 41%
18. Emotional state 49%
Block 4. Social
19. Family support 37%
20. Coaches and team 40%
21. Social recognition 27%
Block 5. Technological
22. Innovations in training equipment 33%
23. Digital technologies 29%
24. Data analytics 25%

The next step in our work was the individual health assessment system, which involved the implementation of a survey before the start of the experiment and at its completion using a personalized health assessment questionnaire (Table 2, Survey questionnaire No. 1 (Appendix b)).

Table 2

Results of 15 subjects (in tabular form) after the survey based on questionnaire No. 1 (Appendix b)

	Questions	Possible answers (points)	Before	After
	General state of health			
1	Have you had any injuries in the last 3 months?	Yes (1)	12	4
		No (0)	3	11
2	Do you have any chronic diseases?	Yes	1	1
		No	14	14
3	Do you experience fatigue or overexertion after training?	Rarely (0)	2	7
		Sometimes (1)	2	4
		Often (2)	11	4
	Have you experienced any sleep disturbances over past month?	No (0)	3	6
		Yes, but rarely (1)	2	3
		Often (2)	10	6
	Level of physical activity			
	How much time do you dedicate to training on a daily basis?	<1 hour (0)	2	1
		1-2 hours (1)	10	4
		>2 hours (2)	3	10
	Does your training program include the following types of exercises?	Cardio	15	15
		Strength exercises	15	15
		Exercises to develop flexibility	15	15
		Rehabilitation exercises	15	15
	How would you rate your physical fitness?	Low (0)	4	1
		Moderate (1)	8	3
		High (2)	3	11
	Diet and hydration			
	Do you keep a special diet?	Yes	3	3
		No	12	12
	How many times a day do you take food?	1-2 times	0	0
		3-4 times	14	13
		5 and more	1	2
	Do you drink sufficient amount of fluid during a day?	Yes	14	13
		No	1	2

continuation of Table 2

Questions	Possible answers (points)	Before	After
Rehabilitation			
Do you use rehabilitation treatment (massage, sauna, cryotherapy)?	**Yes**	**15**	**15**
	No	**0**	**0**
Does your rest program include active recovery (light exercise, walking)?	**Yes**	**15**	**15**
	No	**0**	**0**
How many hours a day do you spend resting or sleeping?	**<6 hours**	**3**	**1**
	6-8 hours	**5**	**11**
	>8 hours	**7**	**3**
Well-being and psychological state			
How do you rate your stress level?	**Low**	**4**	**8**
	Moderate	**7**	**6**
	High	**4**	**1**
Do you feel motivated to train?	**Constantly**	**6**	**8**
	Sometimes	**6**	**6**
	Rarely	**3**	**1**
How do you assess your overall well-being at this moment?	**Good**	**4**	**10**
	Satisfactory	**10**	**5**
	Bad	**1**	**0**

Note. research element – before the start of the experiment (Before) and at the end of the experiment (After).

The diagrams of the survey results on some important questions are presented in Fig. 2. They show that the number of injuries during the experiment decreased from 80% to 27%. The Wilcoxon test shows that at the significance level $p>0.002$ the number of injuries before and after the experiment differ significantly. The number of chronic diseases did not change, which is natural.

The number of overloads has significantly decreased. If before the experiment 73% of respondents often felt tired or overloaded after training, then after the experiment only 47%. According to the Wilcoxon test, the feeling of overloads differs at the significance level of $p>0.007$. During the experiment, sleep was regulated. Before the experiment, 67% of respondents complained of frequent sleep problems, and after the experiment – 40%. At the significance level of $p>0.001$, the medians of the distributions of sleep problems before and after the experiment differ significantly.

The training time and self-assessment of physical fitness increased statistically significantly at the significance level, $p>0.006$ and $p>0.001$, respectively.

The next step of the scientific and methodological analysis was the coordination of the obtained statistical data of the questionnaire and the pedagogical block of research. Before the implementation of the specialized program for the introduction of specialized determinants of motor activity and after its completion, we implemented the well-known test for assessing the aerobic capabilities of the body "Yo-Yo intermitted recovery level 2". The study was conducted in the morning, air temperature +18 degrees, on a natural grass lawn. The level of resilience of the body and functional shifts in the overall ratio of indicators and the obtained statistical data were determined. We also examined the dependence of the indicators of the cardiovascular system (HR) under the influence of exogenous components at the first and second stages of the study. This dependence was presented by us in the form of personalized analytical tables to determine the integral of HR and the exogenous factor of movement intensity.

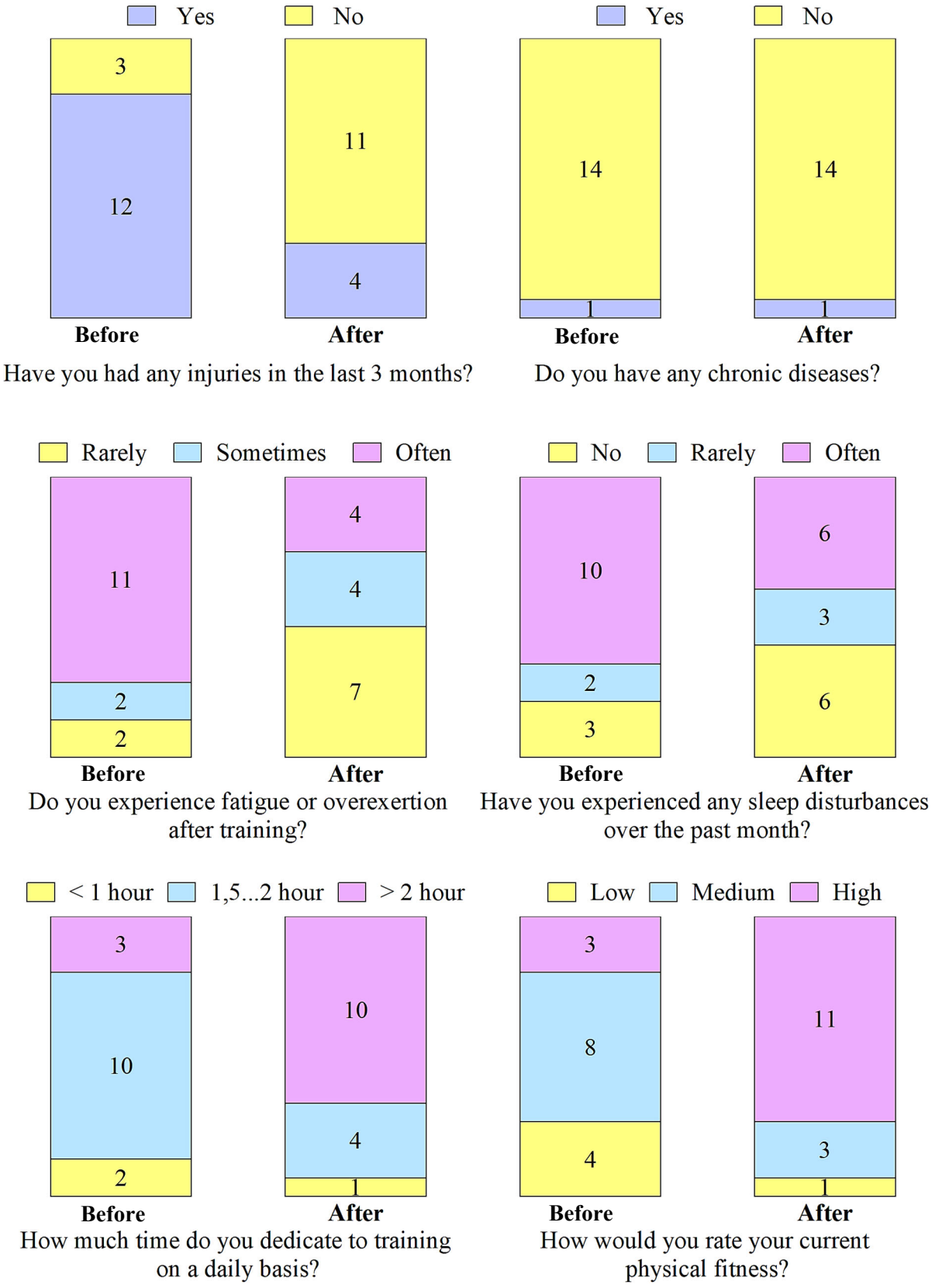

Fig. 2. Diagrams of survey results before and after a special training process

The test was conducted in the range of running speed from 13 km/h to the maximum that the participant can maintain. The highest speed was 19 km/h in participant No. 3 in two tests, and the lowest was

17.5 km/h in participant No. 9 only in the first test. Our assumption about the homogeneity of the physical training of the group is justified. The maximum speed that the participants can maintain is in a narrow interval from 17.5 to 19 km/h.

The special training process increased the maximum speed by 0.5 km/h in almost all participants. The maximum speed did not change only in athletes No. 3, 5, 7, 10, 14. There was no decrease in the maximum speed. Thus, the speed endurance at the maximum speed improved in 10 participants and remained unchanged in 5.

According to the results of Yo-Yo testing, the dependences of heart rate on running speed *HR(v)* were obtained. They turned out to be ambiguous. In some athletes (No. 4, 6, 8, 12) the training process reduced the heart rate for any speed. In others only in certain intervals, usually at high speed (No. 1, 2, 3, 7, 9, 11, 15). Running at low speed changed less. A decrease in HR only at low speed was observed in participant 11, 13. To reduce these dependencies to one quantitative characteristic that can be statistically compared, we integrated the obtained dependencies of HR(v) on running speed within the limits of the test. Accordingly, the following were found: S_1 – integral of HR(v) Yo-Yo-testing before the special program, and S_2 – integral of heart rate(v) after its completion and $\Delta S=S_1$ and S_2 – their difference. The average values of HR within the test were also found – AHR_1, AHR_2 and $\Delta AHR=AHR_1 - AHR_2$. The study revealed that the test time for each athlete almost did not change. Therefore, S_1 and S_2 indicate the total number of heart beats. The higher the integral HR, the more heart beats occurred during the test. Therefore, if S_1 and S_2 is positive, then the integral characteristic of heart rate is considered to have improved. This means that during the Yo-Yo test conducted after the training process according to the special program, fewer heart beats occurred than in the test before the special training process. The results obtained are presented in Table 3 and Figure 3.

Table 3

Integral HR of different athlets in the first and second Yo-Yo-tests

Number of participant	Integral HR			Average HR		
	S_1	S_2	ΔS	AHR_1	AHR_2	ΔAHR
1	775.00	753.25	21.75	155.0	150.7	4.3
2	735.75	668.25	67.50	147.2	133.7	13.5
3	921.00	878.75	42.25	153.5	146.5	7.0
4	758.25	647.75	110.50	151.7	129.6	22.1
5	856.5	830.25	26.25	155.7	151.0	4.8
6	805.25	727.75	77.50	146.4	132.3	14.1
7	759.00	727.50	31.50	138.0	132.3	5.7
8	776.75	660.00	116.75	155.4	132.0	23.4
9	635.5	589.25	46.25	141.2	130.9	10.3
10	764.00	766.00	-2.00	138.9	139.3	-0.4
11	662.75	641.50	21.25	132.6	128.3	4.3
12	833.25	730.25	103.00	151.5	132.8	18.7
13	855.50	824.50	31.00	155.5	149.9	5.6
14	852.25	856.25	-4.00	155.0	155.7	-0.7
15	635.50	647.25	-11.75	141.2	143.8	-2.6

In Figure 3, it can be seen that the average heart rate values in test No. 3 are generally lower than in test No. 1. This is clearly seen in Figure 3b, which shows the difference between AHR_1 and AHR_2. Only in athletes No. 10, 14 and 15 this difference was negative. The largest decrease in average heart rate

occurred in participants No. 4 and 8. It can be assumed that the average heart rate in test No. 2 is lower than in No. 1. This can be verified by testing the statistical hypothesis of equality of means and medians. However, first, the samples must be checked for outliers and for normality of distribution.

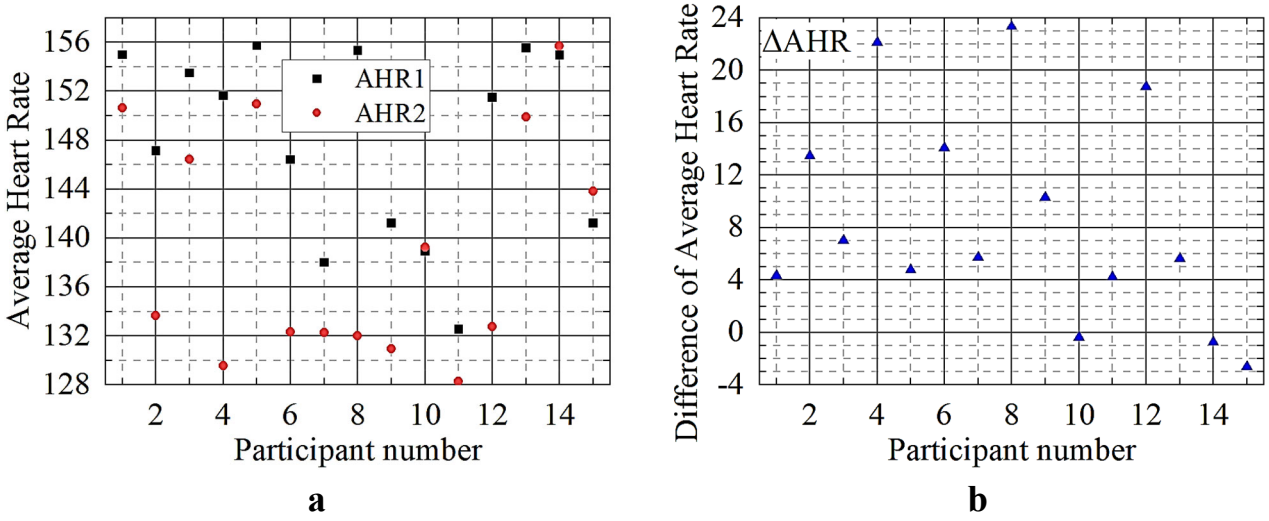

Fig. 3. Integral HR of different athlets in the first and second Yo-Yo-tests and their difference

Outlier statistic of samples S_1 and S_2 using a modified Z-score (M) based on the median and median absolute deviation with an outlier threshold of M=2 showed the absence of gross errors. Usually, the outlier threshold is used at the level of 3.5. The largest deviations from the median were observed in sample S_1 for 3 participants with M_3=1.69. Samples AHR_1 and AHR_2 have worse homogeneity. The largest outlier in sample AHR_1 was in participant No. 11 with M_{11}=3.02. Therefore, the outlier threshold was increased to 3.1, which is acceptable. Thus, we consider that the samples are homogeneous.

Since the sample of the studied subjects was small n=15, we used the Shapiro–Wilk test to test the hypothesis of normal distribution, which is optimal for small samples. The results of the test are presented in Table 4. The integral HRs in the first and second tests and their difference at the 0.05 significance level (W(0.05;15)=0.881) can be considered to be normally distributed. The difference in mean HRs is also normally distributed with p=0.05. However, the mean HRs for the first and second tests at the 0.05 significance level cannot be considered to be normally distributed. These samples can be considered to be taken from a normally distributed population only at a significance level less than 0.03.

Since the Shapiro-Wilk test confirms the hypothesis of normal distribution with p=0.05, the equality of the mean values, can be tested using the parametric t-test. In addition, the hypothesis of equality of the medians was also tested using the Wilcoxon test.

Table 4

Results of Shapiro-Wilk test

Distribution	W	p
ΔS	0.9263	0.240
S_1	0.9439	0.435
S	0.9459	0.462
ΔAHR	0.9304	0.277
AHR_1	0.8744	0.039
AHR_2	0.8686	0.032

The statistical data on the integral heart rate and the results of the parametric t-test and the Wilcoxon test are presented in Table 5. There it can be seen that the mean values and medians of the samples differ significantly with a significance level of p≥0.001. Therefore, it can be stated that at the significance level of p=0.05, the average value of the integral HR during the special training process decreased by ΔS=45.18±22.95 units, which is 5.83±2.96%. The significance level can be increased to a maximum of 0.24 (Table 3). Then, ΔS=45.18±13.13. The average HR also statistically significantly decreases by ΔAHR=8.675±4.498 min^{-1} for the p=0.05 level, which is a decrease of 5.87±3.04%, and ΔAHR=8.675±5.064 min^{-1} for p=0.03.

Table 5

Statistics of integral HR, results of nonparametric t-test and Wilcoxon test

Data	Mean	Standard deviation SD	Median Me	MAD	t-tets		Wilcoxon test	
					t	p	W	p
ΔS	45.18	41.44	31.50	33.50	4.223	0.001	114	0.001
S_1	775.08	83.85	775.00	58.25				
S_2	729.9	88.18	727.75	80.00				
ΔAHR	8.675	8.121	5.727	6.09	4.137	0.001	114	0.001
AHR_1	147.91	7.741	151.50	4.23				
AHR_2	139.24	9.370	133.65	5.35				

Note. Statistical data.

The nonparametric Wilcoxon test (W=114) at the significance level of p>0.001 also shows that the values of S_1 have a significant tendency to be greater than S_2. The median of the sign ΔS=31.5 was positive. The difference between the medians of S_1=775 and S_2 =27.75 is 49.25. Thus, during the special training process, the median of the integral heart rate decreased by 6.10%. The median of the average heart rate decreased from 147.91 to 139.24, i.e. by 5.86%

Thus, taking into account the limitations of the significance level according to the Shapiro-Wilk test for AHR_1 and AHR_2 (Table 4), it can be stated that at the level of 0.001≤p≤0.03 by the t-test and at the significance level p≥0.001 by the Wilcoxon test, the data obtained indicate that as a result of specialized exposure, the integral and average heart rate when performing the Yo-Yo test decreases by an average of 5.8%. The multicombinant relationship between the functional state of the cardiovascular system and the body's ability to have stable progressive resilience to exogenous factors has significantly improved.

In previous studies, Smith J. et al., (2018) [17], Warburton D.E.R. et al. (2018) [18], Sirenko P.O. et al. (2022, 2023, 2024) [3, 10, 11] only the level of development of certain functional qualities was assessed based on local diagnostic measures. The studies were considered isolated, without consideration of factors of generalized influence on general performance and impact on the resilience of the individual's health. Krustrup P. et al., (2006) [7], performance in the aerobic power zone was determined without controlling the heart rate.

We have supplemented and expanded data on the determinants of motor activity of athletes and factors of functional exogenous influence on the performance of the athlete's body in difficult environmental conditions. The structure and system of analysis of personalized perception of load by functional systems (based on the analysis of the cardiovascular system's performance) in combination with endogenous (psychological, emotional) response have been agreed upon.

CONCLUSIONS

1. The essence of the content of the introduction of determinants of motor activity of athletes and the resilience of the individual's health in the context of the endogenous response has been clarified. Including the content with statistically confirmed effectiveness of the impact of the proposed methods in the structure of experimental and research verification of their application.
2. A methodology for the implementation and assessment of the effectiveness of the implementation of individual specialized determinants to the content of the general motor activity of athletes, in particular in professional football has been developed.

3. A methodology for applying an individual program for the development of the functional capabilities of the motor systems of the athlete's body has been established and substantiated. Points regarding the most important components of the determinants of motor activity and their impact on the health of the individual have been identified. The highest percentage, out of 15 subjects, were items 6, 7, 9 of block 1 regarding physiological determinants. Item 6, regarding the general level of physical fitness – 95%; item 7, regarding general endurance – 85%; item 9, regarding strength endurance – 78%. Also, item 12, block 2 regarding medical determinants received 93%.

4. The effectiveness of the influence on the state of the functional systems of the body of professional football players, the use of specialized means of exogenous influence in the structure of the general preparatory and special preparatory stages of the preparatory periods in the direction of general and strength endurance, is statistically substantiated.

5. A positive effect on the general condition of the body has been established (according to the data of the questionnaire, monitoring of heart rate and intensity of movement, analysis of graphic images constructed based on the obtained indicators) and those that determine the development of aerobic and strength capabilities in the context of the general conglomerate of motor activity. The average heart rate during the Yo-Yo test before the special training process is 147.9±4.3 min-1 (p=0.05), with a median of 151.5 min-1. After the special training process, the average heart rate decreased to 139.2±5.2 min-1 (p=0.05), with a median of 133.7 min-1. At the significance level of p>0.001 by the Wilcoxon paired test and by the t-test, the data obtained indicate that the specialized training complex reduced the average value of the integral and average heart rate during the Yo-Yo test. At the significance level of p=0.05, the integral heart rate decreases by ΔS=45.18±22.95 units, which is a decrease of 5.83±2.96%. The average heart rate decreases by ΔAHR =8.68±4.50 min-1, which is a decrease of 5.86±3.04%. The median values of the integral and average heart rate also decreased, respectively by 6.10 and 5.86%. This indicates a decrease in the total number of heart beats per unit load during the Yo-Yo test in the second test compared to the first. Thus, there is a multicombinant relationship between the functional state of the cardiovascular and muscular systems in the context of positive adaptive shifts under the influence of exogenous factors.

6. Analyzing the data, it can be concluded that the level of the functional state of the cardiovascular and muscular systems has significantly improved. The main narrative is a decrease in heart rate with a corresponding increase in the ability to cover a greater distance with greater intensity. We can state about the improvement of the health of the organism and the ability to counteract exogenous factors based on the assessment of the state of the cardiovascular and muscular systems in the subjects, according to the eponymous protocols No. 1-4, 6-13, 15. The ability to maintain high intensity of movement with a change of direction with complicated external regulation in specialized conditions also developed. The power component also received a significant improvement, since an important component in the content of multidirectional overcoming movement is the combination of the structure of eccentric and isokinetic movements in each phase of the completion of the running segment. The correlation of these indicators an excellent endogenous response of shows the body's motor systems, an improvement in the level of fitness, adaptive capabilities, and the body's ability to counteract exogenous factors. A corresponding improvement in the overall functional state of the organism and the resilience of the individual's health. In subjects No. 5 and No. 14, the curve of the main indicators did not tend to improve. Subject No. 5 had a long-term (1 month) infectious disease, subject No. 14 had a limitation of motor activity (1.5 months) due to an occupational injury. The above factors indicate a correlation between the general functional state and the organization of specialized training programs.

7. According to the data of questionnaire No. 1 (Appendix b.1.) regarding the repeated survey of the individual's health assessment, after the implementation of the experimental practical block at the stage of completion of the experiment, it can be stated about the general improvement of the personalized health assessment.

8. We experimentally tested (based on the obtained biological data regarding the endogenous response of the functional systems of the body to factors of external influence and the resilience of the individual's health) the effectiveness of the methods of influencing the determinants of the athletes' motor activity on the state of the body.

The prospect of further research is to identify determinants of physical activity for others, including cyclic sports and people leading an active lifestyle. The proposed practical and diagnostic methods, conditions for their application and regulation can be recommended for the practice of physical therapists, occupational therapists, physical therapy instructors, rehabilitation specialists, and coaches in acyclic sports.

Contributors:

Sirenko P.O. – resources, conceptualization, methodology, writing – review and editing;

Storozhenko I.P. – statistical processing of observation results, verification of biophysical consistency of results;

Sirenko R.R., Kindrat V.K., Yuzyk O.P., Lietuviete D., Kolesnyk T.V. – research methodology, data curation, formal analysis, visualization, research, writing – original draft, supervision.

Funding. This research received no external funding.

Conflict of interests. The authors declare no conflict of interest.

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Стаття надійшла до редакції 05.03.2025;
затверджена до публікації 22.05.2025