GEORGIAN MEDICAL NEWS

ISSN 1512-0112

NO 12 (357) Декабрь 2024

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper formats of the Agency of Medical Information of the Georgian Association of Business Press. Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

**Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.**

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

GEORGIAN MEDICAL NEWS
No 12 (357) 2024

Содержание:

INDIVIDUAL CHARACTERISTICS OF HIGHER NERVOUS ACTIVITY AS A FACTOR IN ADAPTATION AND RECOVERY OF THE CARDIOVASCULAR SYSTEM IN ATHLETES

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Abstract.

Introduction: The aim of this study was to examine the influence of higher nervous activity (HNA) types on heart rate variability (HRV) parameters in athletes after physical exertion. The primary objective was to identify the relationship between HNA types and the body's adaptive capacity, as well as to assess stress resilience and recovery efficiency.

Material and Method: The study involved 144 male athletes aged 17–20 years (mean age: 18.5 ± 1.5 years) engaged in football and track and field. Participants were classified into groups based on their higher nervous activity (HNA) types using the Eysenck Personality Questionnaire (EPQ) and the "Psychotest" software, categorizing them as sanguine, choleric, phlegmatic, or melancholic. Six heart rate variability (HRV) parameters (RMSSD, SDNN, LF/HF, TP, pNN50, HF) were analyzed before and after the Cooper test (12-minute run) using the "Biomouse" hardware-software complex and the specialized "Varicard-2.51" program.

Results: The study revealed significant differences in the cardiovascular system's response to physical exertion among athletes with different higher nervous activity (HNA) types ($p<0.05$). Sanguine individuals exhibited a moderate decrease in RMSSD, SDNN, and TP, indicating balanced regulation of sympathetic and parasympathetic activity. Phlegmatic individuals showed minimal changes, confirming their high adaptive reserves and resilience to physical stress. In contrast, choleric and melancholic individuals demonstrated a significant reduction in RMSSD, SDNN, and TP, along with an increase in LF/HF, suggesting predominant sympathetic activity and heightened regulatory system strain.

These findings highlight greater stress resilience and better adaptive capacities in sanguine and phlegmatic individuals, whereas choleric and melancholic athletes exhibit reduced adaptive potential. Furthermore, following the Cooper test, choleric and melancholic individuals displayed changes characteristic of sympathetic nervous system activation, including an increase in LF/HF and a decrease in pNN50 ($p<0.01$). These results emphasize the importance of considering HNA types when designing individualized training and recovery programs.

Conclusion: The results demonstrate the influence of higher nervous activity (HNA) types on adaptation to physical exertion, emphasizing the importance of a personalized approach to training and recovery programs. This is crucial for enhancing athletic performance and preventing overload and burnout.

Key words. Higher nervous activity, heart rate variability, adaptation, recovery, athletes, stress resilience, individualized approach.

Introduction.

According to various studies, the prevalence of sports injuries and professional burnout among athletes ranges from 20% to 40% [1,2-9]. A survey conducted by the SuperJob portal in 2023 found that one in eight athletes (13%) reported experiencing severe fatigue, while 45% of respondents noted symptoms of such a condition [7]. The International Classification of Diseases, 11th Revision (ICD-11), includes disorders related to professional burnout and chronic stress, which significantly affect athletes' performance and recovery [5]. These conditions are characterized by physical and emotional exhaustion, reduced motivation, and decreased productivity, making them particularly relevant for athletes exposed to intense physical and psychological stress [10,11].

Systematic reviews indicate that under conditions of high competition and significant physical exertion, one-third of athletes experience a wide range of psychological and behavioral issues [12]. Athletes are more prone to professional burnout and psychological disorders compared to other population groups [6,8]. Additionally, genetic factors and the type of higher nervous activity (HNA) play a crucial role in the body's adaptation to stress, recovery processes, and the risk of injuries and burnout [2,13,14]. However, the impact of HNA and genetic factors on these processes remains insufficiently studied, highlighting the need for further research to improve diagnosis and prevention strategies [3,15].

Types of higher nervous activity (HNA) are a key factor in the body's adaptation to physical exertion and stressful situations [4]. Individual HNA characteristics determine cardiovascular and nervous system responses to training loads, making them an important aspect of sports medicine [13]. The body's reaction to physical activity is reflected in heart rate variability (HRV) parameters, which assess the balance between the sympathetic and parasympathetic nervous systems [1,2].

HRV serves as a universal marker of adaptive potential and stress resilience: high HRV values indicate effective recovery and strong functional reserves, whereas low values suggest physiological strain and the need for longer recovery periods [7,6]. Given the critical role of individual HNA traits in adaptation to physical and psychological stress, this study aimed to examine the relationship between HNA types and HRV parameters in athletes. Special attention was given to evaluating the body's adaptive capacity and recovery rate, which are essential for developing personalized training, recovery strategies, and preventing professional burnout [4,5,12].

Methodology.

The study involved 144 male athletes aged 17–20 years (mean age: 18.5 ± 1.5 years) who regularly engaged in football or track and field at the Samarkand Sports School. The first group included 69 football players, while the second group consisted of 75 track and field athletes. All participants held either a second- or third-class sports ranking. The inclusion criteria were regular sports training for at least three years, age between 17 and 20 years, possession of a second- or third-class sports ranking, and absence of significant injuries or illnesses within six months prior to the study. The exclusion criteria included the presence of chronic cardiovascular, nervous, or respiratory system diseases, use of medications affecting heart rate variability (HRV), contraindications to physical activity, and failure to comply with pre-test preparation guidelines such as food or caffeine intake within two hours before testing. To minimize subjectivity in the classification of higher nervous activity (HNA) types, a comprehensive approach was applied, incorporating standardized psychological methods and computer-based programs. The primary tool for assessing HNA type was the Eysenck Personality Questionnaire (EPQ), which has high reliability in identifying key personality traits such as extraversion, introversion, and neuroticism, which were used to classify participants as sanguine, choleric, phlegmatic, or melancholic. Additionally, the "Psychotest" program was used to interpret the results. The system automatically processed EPQ questionnaire data and ensured an objective classification of participants by HNA type. The program also included additional modules for assessing emotional stability and reactivity, refining the psychophysiological profile of each participant. Based on the test results, participants were categorized into four groups: sanguine, choleric, phlegmatic, and melancholic. The obtained data were reviewed by an expert panel consisting of a psychologist and a physiologist, eliminating classification errors and ensuring high accuracy. For the assessment of heart rate variability (HRV), the "Biomouse" hardware-software complex (NeuroLab, Russia) was used. To evaluate functional status, HRV parameters included RMSSD, SDNN, LF/HF, TP, pNN50, and HF, as they serve as key indicators of the autonomic nervous system (ANS) function, which regulates the cardiovascular system and is responsible for the body's adaptation to physical and psycho-emotional stress.

RMSSD (Root Mean Square of Successive Differences) reflects parasympathetic nervous system activity and the body's recovery capacity. Low RMSSD values may indicate increased sympathetic nervous system activity and stress, while high values suggest good recovery levels (normal range: 25–50 ms).

SDNN (Standard Deviation of NN Intervals) evaluates overall heart rate variability and serves as a marker of the body's adaptive capacity. High SDNN values indicate good functional status and recovery ability, whereas low values may suggest reduced adaptive reserves (normal range: 75–130 ms).

LF/HF (Low Frequency to High Frequency Ratio) represents the balance between low-frequency (LF) and high-frequency (HF) components of heart rate variability, reflecting the autonomic balance between sympathetic and parasympathetic activity. Values above 2.0 indicate predominant sympathetic activity, which may signal stress (normal range: 1.2–2.8).

TP (Total Power) represents the overall autonomic nervous system activity and the body's energy reserves. High TP values indicate good recovery and strong adaptive capacity, whereas low values may suggest depletion of these reserves (normal range: 2300–3800 ms^2).

pNN50 (Percentage of successive NN intervals differing by more than 50 ms) demonstrates the degree of parasympathetic nervous system activity and the body's recovery ability after physical exertion. High values indicate good recovery potential, while low values may reflect increased stress levels (normal range: 12–35%).

HF (High Frequency Power) reflects parasympathetic nervous system activity, particularly in relation to respiratory function. High HF values indicate good recovery and low stress levels (normal range: 400–750 ms^2).

To assess physical endurance and adaptive capacity in athletes with different types of higher nervous activity (HNA), the Cooper test was used. This test allowed for the analysis of physiological parameter changes, such as heart rate variability (HRV), under the influence of intense physical exertion and during the recovery period. All participants performed the test on a 400-meter rubberized running track in the morning (between 8:00 and 10:00) to minimize the impact of circadian fluctuations in physiological parameters. The ambient temperature was maintained between 18–22°C, with no precipitation or strong wind.

Before the test, participants completed a 10-minute warm-up, which included light jogging and stretching, to prevent injuries and adapt the cardiovascular system to exertion. During the test, athletes ran at maximum speed for 12 minutes, and the total distance covered was recorded. After completing the test, each participant remained in a seated position for five minutes, during which HRV parameters were measured. The test conditions were standardized for all participants, minimizing the influence of external factors. This approach ensured consistency in testing conditions, allowing for a valid comparison of HRV parameters among athletes with different HNA types. The Cooper test served as a key tool for analyzing physical endurance, autonomic regulation, and recovery, enabling a deeper understanding of athletes' adaptive mechanisms based on their psychophysiological characteristics.

Statistical Analysis.

The statistical analysis of the study data is presented as means and standard deviations (M±m). The chosen statistical methods align with the research objectives and adhere to international standards: the Shapiro–Wilk test was used to assess the normality of data distribution, the paired t-test was applied for pre- and post-Cooper test comparisons in cases of normal distribution, the Wilcoxon signed-rank test was employed for dependent samples with non-normal distribution, and ANOVA was conducted to compare groups based on types of higher nervous activity (HNA). A p-value of <0.05 was considered statistically significant.

Results.

The distribution of study participants by HNA types is shown in table 1.

Studies show (Table 1) that the majority of participants in the study belong to the sanguine type, both among football players

Table 1. Distribution of study participants by types of Higher Nervous Activity (HNA).

Type of HNA	Total number of participants (%)	Football players (number) (%)	Track and field athletes (number) (%)
Sanguines	59 (40,97)	28 (40,6)	31 (41,3)
Cholerics	41 (28,47)	20 (29,0)	21 (28,0)
Phlegmatics	29 (20,14)	15 (21,7)	14 (18,7)
Melancholics	15 (10,42)	6 (8,7)	9 (12,0)
Total	144 (100)	69(100)	75(100)

Table 2. Heart Rate Variability (HRV) Indicators in Athletes with Different Types of Higher Nervous Activity (HNA) Before and After the Cooper Test.

Type of HNA	HRV Indicators	Before Test (M±SD)	After Test (M±SD)	Change (%)	p-value
Sanguines (n=59)	RMSSD (мс)	45±6	40±5	-11%	<0.05
	SDNN (мс)	120±10	110±8	-8%	<0.05
	LF/HF	1.3±0.2	1.6±0.3	+23%	<0.05
	TP (мс²)	3700±500	3400±450	-8%	<0.05
	pNN50 (%)	30±6	25±5	-17%	<0.05
	HF (мс²)	700±90	650±80	-7%	<0.05
Phlegmatics (n=29)	RMSSD (мс)	50±7	47±6	-6%	<0.01
	SDNN (мс)	130±12	125±10	-4%	<0.01
	LF/HF	1.2±0.1	1.4±0.2	+17%	<0.01
	TP (мс²)	3800±520	3600±500	-5%	<0.01
	pNN50 (%)	35±7	30±6	-14%	<0.01
	HF (мс²)	750±95	700±90	-7%	<0.01
Cholerics (N=41)	RMSSD (мс)	38±5	30±4	-21%	<0.01
	SDNN (мс)	110±9	95±8	-14%	<0.01
	LF/HF	1.7±0.3	2.1±0.4	+24%	<0.01
	TP (мс²)	3200±400	2700±350	-16%	<0.01
	pNN50 (%)	20±5	15±4	-25%	<0.01
	HF (мс²)	600±80	500±70	-17%	<0.01
Melancholics (n=15)	RMSSD (мс)	32±4	25±3	-22%	<0.01
	SDNN (мс)	90±6	75±5	-17%	<0.01
	LF/HF	2.2±0.3	2.8±0.4	+27%	<0.01
	TP (мс²)	3000±450	2300±400	-23%	<0.01
	pNN50 (%)	18±4	12±3	-33%	<0.01
	HF (мс²)	470±80	400±70	-15%	<0.01

***Notes:** Min–Max values for indicators: RMSSD: 25–50 ms, SDNN: 75–130 ms, LF/HF: 1.2–2.8, TP: 2300–3800 ms², pNN50: 12–35%, HF: 400–750 ms². Percentage change values are calculated as the relative change before and after the Cooper test.*

and track and field athletes. Out of 144 participants, 40.97% (59 individuals) were classified as sanguine, including 40.6% (28 individuals) from the football group and 41.3% (31 individuals) from the track and field group. This confirms that sanguine individuals, due to their high extraversion and low neuroticism, demonstrate a strong adaptation to physical exertion, making them more inclined to engage in sports. Sanguine individuals typically exhibit high motivation and energy levels, which may explain their dominance in both athlete groups. Choleric individuals accounted for 28.47% of all participants, slightly lower than the proportion of sanguine athletes. Among football players, 29.0% (20 individuals) were classified as choleric, while in the track and field group, this figure was 28.0% (21 individuals). The characteristics of cholerics, such as high neuroticism and strong goal orientation, may explain their participation in high-energy-demanding sports like football and track and field. Phlegmatic individuals comprised 20.14% (29 individuals) of the participants and were present in both athlete groups. However, their proportion was slightly higher among football players (21.7%) than among track and field athletes (18.7%), which could be attributed to their more composed and methodical approach to training. Melancholic individuals formed the smallest group among all HNA types, representing 10.42% (15 individuals). Among football players, melancholics constituted 8.7% (6 individuals), whereas in the track and field group, they accounted for 12.0% (9 individuals). Melancholics generally exhibit higher levels of neuroticism, which may explain their lower inclination toward intensive physical activities. However, their presence in both athlete groups confirms that even individuals of this HNA type can participate in sports despite their heightened sensitivity to stress.

Thus, the study results indicate that sanguine individuals are the most prevalent among football players and track and field athletes, likely due to their tendency for active participation in physical activities and strong adaptability to physical exertion.

The Cooper test was accompanied by moderate changes in all heart rate parameters among athletes with different types of higher nervous activity (HNA). This is likely due to the individual psychophysiological response to physical exertion characteristic of each HNA type. The obtained results emphasize the importance of considering HNA types when assessing adaptive capacity and developing training programs.

The analysis of heart rate variability (HRV) parameters in athletes with different types of higher nervous activity (HNA) before and after the Cooper test is presented in Table 2.

After completing the Cooper test, RMSSD decreased by 11% ($p<0.05$) in sanguine individuals, reflecting moderate tension in parasympathetic regulation. In phlegmatic individuals, the indicator decreased by 6% ($p<0.01$) while remaining at a high level. In choleric and melancholic individuals, RMSSD significantly decreased by 21% ($p<0.01$) and 22% ($p<0.01$), respectively, indicating pronounced strain and dominance of sympathetic activity. Sanguine and phlegmatic individuals exhibited a reduction in SDNN by 8% ($p<0.05$) and 4% ($p<0.01$), respectively, reflecting a slight decrease in overall heart rate variability. In choleric individuals, SDNN decreased by 14% ($p<0.01$), and in melancholic individuals by 17% ($p<0.01$), indicating significant strain on adaptive mechanisms. The LF/HF ratio increased by 23% ($p<0.05$) in sanguine individuals and by 17% ($p<0.01$) in phlegmatic individuals, while remaining within normal limits. In choleric and melancholic individuals, LF/HF increased by 24% ($p<0.01$) and 27% ($p<0.01$), respectively, indicating a dominance of sympathetic activity after exertion. Total power (TP) decreased by 8% ($p<0.05$) in sanguine individuals and by 5% ($p<0.01$) in phlegmatic individuals, reflecting a moderate reduction in energy reserves. In choleric individuals, TP decreased by 16% ($p<0.01$), and in melancholic individuals by 23% ($p<0.01$), indicating significant depletion of adaptive resources. The pNN50 indicator decreased by 17% ($p<0.05$) in sanguine individuals and by 14% ($p<0.01$) in phlegmatic individuals, while remaining relatively high. In choleric and melancholic individuals, the decrease was 25% ($p<0.01$) and 33% ($p<0.01$), respectively, indicating a significant reduction in parasympathetic activity. HF decreased by 7% ($p<0.05$ and $p<0.01$, respectively) in sanguine and phlegmatic individuals, indicating a moderate decline in parasympathetic activity. In choleric individuals, HF decreased by 17% ($p<0.01$), and in melancholic individuals by 15% ($p<0.01$), reflecting a pronounced weakening of parasympathetic regulation after exertion.

Thus, the most significant changes in HRV parameters after the Cooper test were observed in choleric and melancholic individuals, indicating high tension in adaptive mechanisms and a dominance of sympathetic activity. Sanguine and phlegmatic individuals demonstrated more stable parameters, suggesting greater resilience to physical exertion and more effective heart rate regulation.

Discussion.

Differences in physiological responses to physical exertion are associated with the regulation of heart rate. Sanguine and phlegmatic athletes exhibit a balanced interaction between sympathetic and parasympathetic activity, which contributes to greater stress resilience. In contrast, choleric and melancholic athletes experience a predominance of sympathetic activity, leading to increased strain on regulatory mechanisms, reduced heart rate variability (HRV), and prolonged recovery time.

The results of the Cooper test confirmed significant differences in the adaptive capacities of athletes depending on autonomic nervous system (ANS) type. In sanguine individuals, a moderate decrease in RMSSD, SDNN, and TP was observed after physical exertion, indicating high regulatory system resilience and rapid recovery due to the balanced interplay of sympathetic and parasympathetic activity. Phlegmatic athletes showed minimal changes in RMSSD, SDNN, and TP, reflecting a high level of stability and strong adaptive reserves, characteristic of their temperament. Conversely, choleric athletes demonstrated a marked decline in RMSSD and SDNN, combined with an increase in LF/HF, indicating sympathetic dominance and heightened regulatory system strain. This confirms their tendency to exhibit pronounced stress reactions to physical exertion, necessitating additional recovery interventions to maintain physiological balance. In melancholic athletes, a reduction in RMSSD and TP, along with a significant increase in LF/HF, confirms limited adaptive reserves and a dominance of sympathetic activity. These findings indicate the need for extended recovery periods and the development of individualized training approaches tailored to their physiological characteristics. Analysis of the results suggests that physical exertion in athletes with a less balanced nervous system leads to dysregulation of heart rate control mechanisms. This may be explained by the reduced ability of the central nervous system (CNS) to effectively manage the balance between sympathetic and parasympathetic activity.

Studies conducted in other countries report similar findings. In the study by Villareal et al. (2021), a comparison of adaptive capacities in athletes with different HNA types demonstrated that individuals with higher RMSSD and SDNN values exhibit superior recovery abilities. This aligns with our findings for sanguine and phlegmatic athletes, who maintained relatively high RMSSD and SDNN values after the Cooper test, confirming a well-balanced interplay between sympathetic and parasympathetic activity, facilitating faster recovery. Conversely, the research by Smith et al. (2020) highlights a decrease in RMSSD and SDNN in athletes with less balanced nervous system regulation, which is consistent with the patterns observed in choleric and melancholic athletes in our study.

Sympathetic Dominance in Choleric and Melancholic Athletes.

In our study, choleric and melancholic athletes exhibited a significant increase in LF/HF following physical exertion, indicating a dominance of sympathetic activity and heightened strain on adaptive mechanisms. Wang et al. (2022) report that elevated sympathetic activity is associated with prolonged recovery time and an increased risk of overtraining, which aligns with our findings.

Role of Psychoemotional Resilience.

Research by Malik et al. (2019) highlights that stress resilience and low anxiety levels contribute to more efficient heart rate regulation. In our study, sanguine and phlegmatic athletes generally demonstrated more stable psychoemotional regulation, as evidenced by their consistent HRV parameters, reinforcing their greater physiological adaptability to stress and recovery efficiency.

Practical Implications for sports medicine.

Personalization of training programs – the findings emphasize the necessity of considering individual HNA characteristics in training program development. Extended recovery for sympathetically dominant athletes - choleric and melancholic athletes require longer recovery periods and reduced training intensity to prevent excessive autonomic strain. Standard training approaches for adaptive athletes - sanguine and phlegmatic athletes can adhere to standard training protocols, as their adaptive reserves allow them to sustain high-intensity loads with more efficient recovery.

The findings of this study have practical significance not only for optimizing training programs but also for preventing sports burnout, which is a critical issue in both professional and amateur sports. Burnout syndrome is characterized by chronic physical and emotional exhaustion, decreased motivation, and a decline in athletic performance, which are associated with autonomic nervous system (ANS) imbalance, impaired recovery mechanisms, and high levels of chronic stress.

HRV as an Objective Marker of Burnout Susceptibility.

The study demonstrated that athletes with different types of higher nervous activity (HNA) respond differently to physical exertion, as evidenced by changes in heart rate variability (HRV) parameters after the Cooper test.

Identified physiological patterns and their association with burnout risk: Sanguine and phlegmatic athletes exhibit moderate reductions in RMSSD, SDNN, and TP post-exercise, with rapid recovery, indicating high adaptive reserves and a lower risk of burnout. Choleric and melancholic athletes show a significant decline in RMSSD and SDNN, alongside a sharp increase in LF/HF, indicating dominance of sympathetic activity, increased autonomic system load, and delayed recovery. These findings confirm that HRV indicators can serve as predictors of burnout risk, as their changes reflect the level of adaptive stress on the body. Athletes with pronounced sympathetic dominance (cholerics and melancholics) require more rigorous monitoring of training loads and recovery strategies.

Development of personalized burnout prevention strategies.

Based on the study results, individualized approaches to training processes and recovery can be proposed: HRV monitoring in training programs – pegular assessment of RMSSD, SDNN, and LF/HF to detect early signs of ANS imbalance, allowing for timely adjustments in training loads and minimizing stress overload; regulation of training volumes - choleric and melancholic athletes require reduced training intensity during high-stress periods (e.g., pre-competition phases) due to their more vulnerable adaptive mechanisms; implementation of active recovery strategies - incorporating breathing techniques, meditation, and HRV-based training to normalize HRV parameters and mitigate the effects of chronic stress personalized psychophysiological preparation programs - psychological training, cognitive-behavioral therapy (CBT), and self-regulation techniques can reduce anxiety levels, which is particularly crucial for melancholic athletes.

Significance of the Study for Burnout Prevention in Sports.

The results of this study confirm that considering individual characteristics of higher nervous activity (HNA) and heart rate variability (HRV) parameters enables the identification of athletes prone to emotional exhaustion and overtraining. The implementation of a personalized approach to training loads tailored to different HNA types enhances training efficiency. Using HRV as an objective marker of burnout risk allows for better control over stress-induced overload, while the development of comprehensive recovery programs aims to optimize adaptive mechanisms and prevent chronic fatigue. Thus, this study demonstrates that HRV analysis combined with HNA assessment enables the development of individualized burnout prevention strategies. The findings confirm that athletes with heightened sympathetic activity are more susceptible to stress-induced exhaustion, necessitating a tailored approach to training, recovery, and psychological support. These insights can be utilized to optimize sports training and prevent professional burnout in athletes.

Integration of HRV Data into Athlete Monitoring.

Utilizing HRV as a marker provides an objective assessment of an athlete's functional state. International studies, such as Heart Math Institute (2020), confirm that regular HRV monitoring enables real-time adjustments to training loads, thereby enhancing training efficiency and optimizing performance.

Future Research Perspectives.

Further research is required with larger sample sizes, incorporating athletes from various sports and age groups. Additionally, it is crucial to examine the impact of factors such as sleep patterns, nutrition, and psychological preparation on adaptive processes in athletes with different types of higher nervous activity (HNA). Thus, the findings of this study emphasize the importance of integrating psychophysiological data into sports medicine. Considering individual HNA characteristics not only improves athletes' adaptation to training loads but also facilitates the development of personalized training and recovery strategies, thereby reducing the risk of injuries and overtraining.

Potential Limitations and Sources of Error.

For a deeper understanding of the relationship between HNA types and adaptive processes, future studies should involve larger cohorts and employ diverse psychophysiological assessment methods. Moreover, it is essential to consider psychological factors such as anxiety levels and stress resilience, which significantly influence athletes' adaptive capacities.

Conclusion.

The obtained results demonstrate the impact of higher nervous activity (HNA) types on adaptation to physical exertion, emphasizing the importance of a personalized approach to training and recovery. This is crucial for enhancing athletic performance and preventing overload and burnout.

Conflict of interest.

Authors declare about not having financial and personal interests.

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АННОТАЦИЯ

Индивидуальные особенности высшей нервной деятельности как фактор адаптации и восстановления сердечно-сосудистой системы у спортсменов

Введение: Целью данного исследования было изучить влияние типов высшей нервной деятельности (ВНД) на показатели вариабельности сердечного ритма (ВСР) у спортсменов после физической нагрузки. Основной задачей было выявить взаимосвязь между типами ВНД и адаптационными возможностями организма, а также оценить стрессоустойчивость и эффективность восстановления.

Материалы и методы: В исследовании приняли участие 144 спортсмена мужского пола в возрасте 17-20 лет (средний возраст 18,5 ± 1,5 лет), занимающихся футболом и лёгкой атлетикой. Участники были классифицированы по типам высшей нервной деятельности (ВНД) с использованием опросника Айзенка (EPQ) и программы «Психотест» на группы: сангвиники, холерики, флегматики и меланхолики. Были проанализированы 6 показателей вариабельности сердечного ритма (ВСР) (RMSSD, SDNN, LF/HF, TP, pNN50, HF) до и после выполнения теста Купера (12-минутный бег) с использованием аппаратно-программного комплекса «Biomouse» и специализированной программы «Варикард-2.51».

Результаты: Исследование показало значительные различия в реакции сердечно-сосудистой системы на физическую нагрузку у спортсменов с различными типами ВНД ($p<0,05$). У сангвиников наблюдалось умеренное снижение RMSSD, SDNN и TP, что указывает на сбалансированное регулирование симпатической и парасимпатической активности. У флегматиков изменения были минимальными, что подтверждает их высокие адаптационные резервы и устойчивость к физическим нагрузкам. У холериков и меланхоликов наблюдалось значительное снижение RMSSD, SDNN и TP, а также увеличение LF/HF, что свидетельствует о преобладании симпатической активности и напряжении регуляторных систем. Эти данные подчеркивают более высокую стрессоустойчивость и лучшие адаптационные способности у сангвиников и флегматиков, в то время как у холериков и меланхоликов наблюдаются сниженные адаптивные возможности. Кроме того, после теста Купера холерики и меланхолики показали изменения, характерные для активации симпатической нервной системы, такие как повышение LF/HF и снижение pNN50 ($p<0,01$). Эти результаты подчеркивают важность учета типов ВНД при разработке индивидуализированных тренировочных и восстановительных программ.

Заключение: Результаты демонстрируют влияние типов ВНД на адаптацию к физической нагрузке, подчеркивая важность персонализированного подхода к тренировочным и восстановительным программам. Это имеет ключевое значение для повышения спортивных результатов и предотвращения перегрузок и выгорания.