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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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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.

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STRESS RESILIENCE AND DECISION-MAKING UNDER PRESSURE: ENHANCING ATHLETIC PERFORMANCE IN COMPETITIVE SPORTS

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Abstract.

This study investigates the cognitive and neurobiological mechanisms behind decision-making under stress in competitive sports, focusing on how the development of decision-making skills enhances stress resilience and improves athletic performance. The research examines how high-pressure environments affect athletes' ability to make quick decisions and explores effective training methods, including video-based feedback and virtual reality simulations. The study draws on cognitive-behavioral, neurobiological, and ecological models to analyze key findings from empirical research. Results indicate that targeted cognitive training, particularly through video simulation and virtual reality, significantly improves decision-making abilities under stress, enhancing emotional regulation and cognitive flexibility. These improvements are crucial for athletes in maintaining high performance under pressure. The research concludes that integrating decision-making training into sports preparation not only boosts immediate competitive results but also strengthens long-term stress resilience and mental health.

Key words. Stress resilience, decision-making, cognitive flexibility, competitive sports, virtual reality training, emotional regulation, neurobiology, athlete performance.

Introduction.

In the high-stakes world of competitive sports, athletes continuously make swift, decisive choices under immense pressure. These decisions—whether tactical adjustments during play, strategic planning before a competition, or split-second reactions to an opponent's actions—can determine the outcome of their performance and, ultimately, their success or failure. The complexity of decision-making in sports is magnified by the need for athletes to perform optimally under stress, where physical, emotional, and cognitive demands peak simultaneously. Understanding how decision-making under such conditions interacts with stress resilience and affects athletic performance has become a critical area of research in sports psychology, neurobiology, and cognitive science.

Decision-making in competitive environments involves a range of cognitive functions, including information processing, problem-solving, and adapting strategies based on evolving circumstances. Athletes must assess multiple variables—such as the positioning of their opponents, the tempo of the game, and the physical state of both them and their teammates. These variables must be integrated quickly to guide immediate actions. What differentiates elite athletes from their less successful counterparts is not only their physical prowess but also their ability to make rapid, accurate decisions under pressure. Research suggests that decision-making abilities are intertwined with an athlete's capacity to manage stress. Athletes who are more resilient to stress tend to make better decisions [1-4].

Stress resilience refers to an athlete's ability to maintain cognitive and emotional stability under pressure, enabling them to perform consistently despite external stressors like high expectations, competition stakes, and physical fatigue. In competitive environments, stress has been shown to impair cognitive functioning, particularly in areas such as attention, working memory, and decision-making. The neurobiological impact of stress on decision-making is profound, with research highlighting how stress hormones such as cortisol can interfere with the prefrontal cortex—the brain region responsible for executive functions, including decision-making, emotional regulation, and problem-solving [5-7]. Elevated stress level's slow reaction times, impair judgment, and increase the likelihood of errors—outcomes that can be detrimental to an athlete's performance.

However, athletes who demonstrate high stress resilience often display superior decision-making skills under pressure. This ability is supported by neuroplasticity, the brain's ability to reorganize itself by forming new neural connections in response to experience [8]. Over time, repeated exposure to stress in competitive environments strengthens the neural circuits responsible for decision-making, allowing athletes to make more adaptive decisions even when under pressure, and according to Damasio's somatic marker theory, people use these emotional signals (physiological reactions) to predict the likely consequences of their decisions, which ultimately helps them make more adaptive choices [9,10]. This suggests that stress resilience and decision-making are mutually reinforcing processes. Athletes who manage stress effectively are more likely to make sound decisions, while those with strong decision-making skills are better equipped to navigate stressful situations without becoming overwhelmed.

The intersection of decision-making and stress resilience has garnered increasing attention in both cognitive science and sports psychology. Theoretical frameworks such as the Ecological Model of Decision-Making emphasize that decision-making in sports is not just a cognitive process but one deeply embedded in the athlete's interaction with their environment [11]. In this model, athletes constantly adapt their actions based on real-time feedback from the environment—whether it is the movement of an opponent, the behavior of a teammate, or shifts in the game's dynamics. The ability to interpret and act on this feedback quickly and accurately is crucial for success, and stress resilience plays a key role in maintaining this adaptive capacity under high-pressure conditions. Athletes who lack resilience may struggle to process environmental cues effectively, leading to suboptimal decisions that can negatively impact performance.

Moreover, cognitive flexibility, the ability to switch between different mental tasks and strategies, is critical for decision-making under stress [12]. Athletes often face unpredictable, fast-paced situations where they need to adapt their approach quickly. Those with greater cognitive flexibility can transition smoothly between offensive and defensive strategies, anticipate their opponent's moves, and modify their responses based on the evolving context of the game [13]. This cognitive agility is essential for handling the stressors of competition, as athletes are required to make multiple decisions in rapid succession, often with limited information and time constraints [14].

Given the central role of decision-making in competitive sports, researchers have explored various training methods to enhance athletes' decision-making abilities, particularly under stress [15,16]. Techniques such as video-based feedback, virtual reality simulations, and metacognitive strategies have been developed to help athletes practice decision-making in high-pressure scenarios. These methods allow athletes to experience realistic game situations in controlled environments, enabling them to refine their decision-making processes without the immediate consequences of a live competition [17]. Video simulations, for example, present athletes with various game scenarios and allow them to practice anticipating and reacting to their opponents' actions. Similarly, virtual reality creates immersive environments where athletes can engage in decision-making exercises, helping to build cognitive flexibility and stress resilience by replicating the intensity and unpredictability of real competition [18].

Additionally, metacognitive strategies—which involve self-monitoring and self-regulation during decision-making—have proven effective in enhancing athletes' performance under stress. These strategies enable athletes to reflect on their decision-making processes, identify areas for improvement, and adjust their approach in future situations. Research shows that athletes who employ metacognitive strategies make better decisions under pressure and experience improved emotional regulation, as they are better able to manage the anxiety and stress associated with competition [19].

This study aims to explore the complex relationship between decision-making and stress resilience in athletes, examining how cognitive training methods can enhance these skills to improve both performance and mental health outcomes. By investigating the neurobiological underpinnings of stress and decision-making, and evaluating the effectiveness of decision-making training techniques, this research provides valuable insights into how athletes can optimize their performance under pressure. Specifically, the study seeks to understand how targeted decision-making training can improve cognitive flexibility and emotional regulation, two critical factors in maintaining peak performance during competition. The findings offer practical implications for coaches and sports psychologists in developing more effective training programs that support athletes' mental and physical well-being in the face of competitive stress.

Methodology.

This study utilizes a theoretical research design to investigate the relationship between decision-making processes under stress and stress resilience in competitive sports. The approach integrates literature from cognitive-behavioral, neurobiological, and ecological models to understand the cognitive and emotional mechanisms underlying decision-making under pressure.

Literature Review:

A comprehensive literature review was conducted, focusing on three primary areas:

1. Decision-making in sports: Cognitive flexibility, real-time decision-making, and the ecological model of decision-making [11].
2. Neurobiological underpinnings of decision-making: The impact of stress hormones like cortisol on the prefrontal cortex and its role in decision-making under pressure [6].
3. Training interventions: An evaluation of video-based feedback, virtual reality simulations, and metacognitive strategies to enhance decision-making skills in athletes [17,20].

Data Sources: Secondary data was sourced from peer-reviewed journal articles and empirical studies accessed through databases such as PubMed, Scopus, and Google Scholar. Selection criteria focused on research related to decision-making processes, stress resilience, and training methods aimed at enhancing performance under pressure.

Ethical Considerations: Since this study is a theoretical analysis based on existing research, no direct data collection involving human subjects was conducted. All sources used were peer-reviewed and ethically published, ensuring the integrity of the secondary data analysis.

Results and Discussion.

In competitive sports, the ability to make quick and accurate decisions can be the determining factor between victory and defeat. The systemic study of decision-making in sports is a crucial field that plays a significant role in the overall performance of athletes. Athletes face constant decision-making challenges, ranging from tactical choices during the game to strategic planning outside the field, all of which substantially impact their performance.

The decision-making process in sports has unique characteristics that depend largely on the individual making the decisions. Athletes, coaches, referees, and other stakeholders all play a key role in influencing the outcome of a game. Johnson highlighted three key attributes that define decision-making in sports:

1. Natural Context of Decisions: In sports, decisions are made within the specific context of the sports environment. This contrasts with laboratory-controlled settings, where decision-making is often studied. The dynamic and unpredictable nature of real-world sporting scenarios adds complexity to the decision-making process, as athletes and coaches must adapt to continuously changing conditions.
2. Dynamic Nature of Decisions: Johnson argues that decisions in sports are dynamic and evolve over time. This dynamic nature involves both an internal process, where athletes constantly assess and process information, and an external component, which requires continuous information intake from the surrounding environment. This dual aspect of dynamism emphasizes the need to consider the evolving context of decision-making during the course of a game.

3. Real-Time Decision-Making: The third characteristic is the real-time nature of decisions in sports. Athletes and coaches often make decisions under high pressure and time constraints. Whether it's a player making a quick decision on the field or a coach adjusting strategy at a critical moment, the demands of live gameplay require fast and adaptive decision-making [21].

One of the prominent theories in sports decision-making is the “ecological approach” proposed by Araújo, Davids, and colleagues. According to this model, athletes make decisions based on their interaction with the environment, with the goal of achieving a specific objective. The process is cyclical: athletes seek out information to guide their actions, and their actions, in turn, generate new information. This cycle of "acting to seek information and seeking information to act" forms the basis of decision-making in sports.

The ecological model suggests that decision-making effectiveness depends on an athlete's ability to perceive and process relevant information and select appropriate movements based on that information. This model highlights several key aspects of decision-making:

- Contextual Information: The ability to find and apply context-specific information is crucial.
- Limiting Action Options: Decision-making efficiency improves when athletes reduce the number of available action options by focusing on relevant sources of information.
- Constraints on Decision-Making: Experience and other personal constraints can affect the decision-making process and its effectiveness.
- Interaction Patterns: Stable interaction patterns between decision-makers and their environment can be identified and measured.
- Behavioral Transitions: Shifts in behavior are the result of the interaction of multiple constraints, rather than the influence of a single controlling factor [6].

Raab’s T-ECHO model further advances the understanding of decision-making under time constraints. It explains how athletes make tactical decisions based on dynamic shifts in their needs and motivations. In high-pressure situations, athletes often rely on implicit knowledge rather than deliberate reasoning, as the latter requires more time and cognitive resources. Raab’s model suggests that in scenarios with limited time, decisions are often made based on perception-action associations, which allow for quick responses [22].

Stress is a significant factor influencing decision-making in sports, particularly in high-stakes scenarios. The Yerkes-Dodson law explains the relationship between stress and performance, proposing that moderate levels of stress can enhance performance, but excessive stress impairs cognitive functions. This is particularly relevant in complex tasks such as decision-making under pressure [23]. Kahneman and Tversky’s prospect theory further adds that individuals, including athletes, tend to become more risk-averse when faced with potential losses, which can manifest in overly cautious play or unnecessary risks during critical moments [24]. This risk aversion is often exacerbated in high-pressure situations, where stress levels are elevated, and decision fatigue—a state where prolonged decision-making depletes mental resources—becomes a key issue [25-27]. Decision fatigue leads to suboptimal choices, where athletes might act impulsively or make poorly calculated decisions, particularly in the latter stages of a game or competition.

The importance of cognitive flexibility—the ability to adapt decision-making strategies based on changing circumstances—is highlighted by Sanchez-Lopez et al. This flexibility allows athletes to process multiple stimuli simultaneously, such as the positioning of teammates and opponents, and adjust their actions accordingly [28]. Cognitive flexibility is especially crucial in fast-paced team sports, where athletes must continuously reassess their decisions and adapt to evolving situations. In sports like tennis or fencing, this ability enables athletes to switch rapidly between offensive and defensive strategies, evaluating their opponent's moves and adjusting their responses within milliseconds. However, stress can complicate this cognitive flexibility, reducing the efficiency of these mental adjustments during high-pressure moments [29].

The integration of these theoretical models—Johnson’s framework, the ecological approach, Raab’s T-ECHO model, Decision Field Theory, and the concept of cognitive flexibility—provides a comprehensive understanding of the role decision-making plays in both performance and stress resilience in sports. Effective decision-making processes allow athletes to quickly adapt to dynamic environments, process critical information, and execute actions that are aligned with their long-term performance objectives. These processes are not only influenced by cognitive strategies but also shaped by the constraints of the sporting environment, personal experience, and external stressors.

In addition to the theoretical models and cognitive processes underlying decision-making in sports, it is crucial to consider the neurobiological foundations that influence decision-making under stress. These biological mechanisms further deepen our understanding of how athletes respond to high-pressure situations and how stress affects their ability to make optimal decisions. Integrating insights from neurobiology allows us to explore how stress directly impacts brain function and contributes to variations in decision-making effectiveness.

The prefrontal cortex (PFC) is crucial for decision-making, particularly in tasks requiring planning and adaptability. Under normal conditions, the PFC allows athletes to weigh options and make reasoned decisions. However, under stress, the PFC’s functioning can be compromised. Elevated levels of cortisol, a stress hormone, impair the PFC’s capacity to process complex information [6]. As a result, athletes may experience slower reaction times and suboptimal decisions.

The somatic marker hypothesis proposed by Damasio offers further insights into how emotions influence decision-making. This hypothesis suggests that prior experiences stored as "somatic markers" (emotional memories) guide decision-making [9]. Under stress, athletes rely on these markers to make rapid decisions. When emotional responses are well-calibrated, they enhance decision-making; when disproportionate (e.g., heightened anxiety), they hinder performance.

Repeated exposure to high-pressure situations leads to neuroplasticity, allowing athletes to develop stronger neural circuits for decision-making. Han et al. emphasized that athletes regularly engaged in high-stress environments are better at maintaining cognitive flexibility under pressure [30].

Additionally, amygdala activation during stress can lead to emotionally driven decisions, especially if athletes struggle with emotional regulation [31,32].

Given the significant influence of stress on both cognitive and neurobiological processes, various training interventions have been developed to enhance decision-making under stress. These interventions focus on improving athletes' cognitive flexibility, emotional regulation, and resilience, ensuring that they can make better decisions during high-pressure situations.

One common approach is video-based feedback, which allows athletes to review and analyse their performance to improve decision-making skills. García-González et al. demonstrated that video-based feedback significantly enhances athletes' decision-making abilities by enabling them to anticipate opponents' actions and adjust strategies. The cognitive theory of self-regulation underpins its effectiveness, as athletes self-monitor and reflect on their decision-making processes during game analysis [20,33].

Another innovative approach is Virtual Reality (VR) training, which immerses athletes in high-pressure, simulated environments that mimic real-life competitive scenarios [34,35]. In a study conducted by Page et al. and colleagues, basketball players were divided into groups where one group engaged in VR-based training, another viewed basketball games on a computer (CS), and a control group watched playoff game highlights (CTRL). Decision-making performance was evaluated using two types of game scenarios: "training" games, which were part of the VR and CS training, and "non-training" games that were introduced only during the final test. The results indicated that both VR and CS groups outperformed the CTRL group in training game scenarios, with the VR group showing a significant advantage in non-training game scenarios as well. This suggests that while computer-based training enhances the transferability of decision-making skills, VR training not only ensures transferability but also facilitates the generalization of these skills to real-life competitive situations. Thus, VR training offers athletes a more comprehensive method for improving decision-making under pressure, making the skills learned in virtual environments more applicable to actual competition [36].

In addition to these methods, metacognitive training teaches athletes to reflect on their cognitive processes and self-regulate their decision-making under pressure. Lovygina et al. showed that athletes who trained in metacognitive strategies improved both emotional regulation and cognitive flexibility, which are crucial for making optimal decisions during stressful situations [19]. Flavell's model of metacognition emphasizes awareness and regulation, enabling athletes to adjust their behavior in real-time to better navigate high-pressure scenarios [37].

Finally, a multi-modal approach that integrates video-based feedback, VR training, and metacognitive strategies presents the most comprehensive solution for enhancing decision-making under stress. Gabbett et al. argue that combining these methods equips athletes with both cognitive and emotional tools necessary for managing complex decision-making tasks, particularly in high-pressure environments. Such integrative approaches ensure that athletes can maintain high levels of performance, even under significant stress, by building resilience and sharpening their decision-making capabilities [38].

Future research on decision-making training in athletes should focus on the long-term effectiveness and sustainability of current interventions, such as VR training, video-based feedback, and metacognitive strategies. While these methods have demonstrated significant improvements in decision-making skills, particularly under pressure, there is a need to explore whether these gains persist over time and across different sports contexts. Studies like those by Peige et al. have shown the transferability of VR-based decision-making skills from controlled environments to actual competitive scenarios, but further research is required to assess the durability of these effects. Additionally, combining multiple training approaches could enhance overall cognitive resilience, making athletes more adaptable in high-pressure situations. The incorporation of neurobiological assessments could also offer deeper insights into the neural adaptations resulting from decision-making training, thus refining and optimizing these interventions for long-term success.

Conclusion.

This research highlights the crucial role of decision-making in competitive sports, particularly under stress. The findings suggest that cognitive flexibility, emotional regulation, and stress resilience are key factors in optimizing athletic performance. Athletes who demonstrate greater cognitive flexibility and resilience to stress are better equipped to make effective decisions in high-pressure situations. Neurobiological insights reveal how stress hormones like cortisol impair decision-making by disrupting the functioning of the prefrontal cortex and amygdala, further underscoring the importance of emotional regulation.

Training interventions, including video-based feedback, virtual reality simulations, and metacognitive strategies, have proven effective in improving athletes' decision-making abilities. The integration of these methods offers a comprehensive solution for enhancing decision-making under stress, ultimately improving both athletic performance and mental resilience. These findings provide valuable insights for coaches and sports psychologists seeking to develop training programs that optimize performance under competitive pressure.

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Аннотация

В этом исследовании изучаются когнитивные и нейробиологические механизмы принятия решений в условиях стресса в соревновательных видах спорта, уделяя особое внимание тому, как развитие навыков принятия решений повышает стрессоустойчивость и улучшает спортивные результаты. В исследовании изучается, как среда с высоким давлением влияет на способность спортсменов быстро принимать решения, и изучаются эффективные методы обучения, включая обратную связь

на основе видео и симуляции виртуальной реальности. Исследование опирается на когнитивно-поведенческие, нейробиологические и экологические модели для анализа ключевых результатов эмпирических исследований. Результаты показывают, что целевая когнитивная тренировка, особенно с помощью видеосимуляции и виртуальной реальности, значительно улучшает способность принимать решения в условиях стресса, усиливая эмоциональную регуляцию и когнитивную гибкость. Эти улучшения имеют решающее значение для спортсменов в поддержании высокой производительности в условиях давления. Исследование приходит к выводу, что интеграция обучения принятию решений в спортивную подготовку не только повышает немедленные результаты соревнований, но и укрепляет долгосрочную стрессоустойчивость и психическое здоровье.

Ключевые слова: стрессоустойчивость, принятие решений, когнитивная гибкость, соревновательные виды спорта, тренировка в виртуальной реальности, эмоциональная регуляция, нейробиология, спортивная результативность.

აბსტრაქტი

ეს კვლევა იკვლევს შემეცნებით და ნეირობიოლოგიურ მექანიზმებს სტრესის პირობებში გადაწყვეტილების მიღების უკან კონკურენტულ სპორტში, ფოკუსირებულია იმაზე, თუ როგორ აძლიერებს გადაწყვეტილების მიღების უნარის განვითარებას სტრესისადმი მდგრადობას და აუმჯობესებს სპორტულ შესრულებას. კვლევა შეისწავლის თუ როგორ მოქმედებს მაღალი წნევის გარემო სპორტსმენების უნარზე, მიიღონ სწრაფი გადაწყვეტილებები და იკვლევს ვარჯიშის ეფექტურ მეთოდებს, მათ შორის ვიდეოზე დაფუძნებულ უკუკავშირს და ვირტუალური რეალობის სიმულაციას. კვლევა ეყრდნობა კოგნიტურ-ბიჰევიორალურ, ნეირობიოლოგიურ და ეკოლოგიურ მოდელებს ემპირიული კვლევის ძირითადი დასკვნების გასაანალიზებლად. შედეგები მიუთითებს, რომ მიზანმიმართული შემეცნებითი ტრენინგი, განსაკუთრებით ვიდეო სიმულაციისა და ვირტუალური რეალობის საშუალებით, მნიშვნელოვნად აუმჯობესებს გადაწყვეტილების მიღების უნარს სტრესის პირობებში, აძლიერებს ემოციურ რეგულაციას და კოგნიტურ მოქნილობას. ეს გაუმჯობესებები გადამწყვეტია სპორტსმენებისთვის ზეწოლის ქვეშ მაღალი შესრულების შესანარჩუნებლად. კვლევა ასკვნის, რომ გადაწყვეტილების მიღების ტრენინგის ინტეგრირება სპორტულ მომზადებაში არა მხოლოდ აძლიერებს მყისიერ კონკურენტულ შედეგებს, არამედ აძლიერებს სტრესის გრძელვადიან გამძლეობას და ფსიქიკურ ჯანმრთელობას.

საკვანძო სიტყვები: სტრესის მდგრადობა, გადაწყვეტილების მიღება, კოგნიტური მოქნილობა, კონკურენტული სპორტი, ვირტუალური რეალობის ვარჯიში, ემოციური რეგულაცია, ნეირობიოლოგია, სპორტსმენის შესრულება