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SCIENTIFIC RATIONALE FOR THE APPLICATION OF RECOVERY AND ERGOGENIC STRATEGIES IN MARTIAL ARTS AND COMBAT SPORTS

Relevance of problem. *The use of non-prohibited pharmacological and nutraceutical agents with ergogenic and restorative properties should be grounded in a comprehensive understanding of the mechanisms through which they influence metabolic functions that support physical performance, as well as the processes that may limit it. Evidence-based application of these agents, taking into account their specific biochemical and physiological effects, is essential for effectively enhancing the ergogenic potential and optimizing the functional capacity of practitioners of martial arts and combat sports.*

Aim of the study. *To define strategic and tactical approaches for providing sports pharmacology and nutrition specialists, as well as coaches, with modern medical and biological technologies for performance optimization and recovery.*

Methods. *Analysis and generalization of data of modern scientific literature, alongside surveys of experts, athletes, and coaches.*

Results. *Martial arts, recognized globally both as a means of motor skill development and as an effective form of self-defense, necessitate the systematic application of ergogenic and restorative aids to support health, sustain quality of life, and optimize athletic proficiency. Combat sports, largely derived from Eastern martial traditions, impose substantial physiological and psycho-emotional demands due to the complexity of techniques, predominance of eccentric loading, and high levels of stress, thereby requiring targeted pharmacological and nutritional support. These considerations underscore the critical importance of structured evaluation and implementation of such interventions. The primary step involves the identification of the key metabolic shift inherent in any extratraining pharmacological or nutraceutical intervention, as this shift forms the foundation for subsequent physiological adaptations. Furthermore, the contemporary methodological framework for assessing the efficacy of these interventions must account for subtle, species-specific metabolic responses to distinct categories of extratraining stimuli. When integrated with pedagogical performance indicators, this approach facilitates a comprehensive and evidence-based evaluation of the appropriateness, validity, and overall effectiveness of ergogenic and restorative strategies in martial arts and combat sports.*

Key words: *martial arts, combat sports, ju-jutsu, post-exercise recovery, physical performance, ergogenic aids, metabolism.*

Introduction. The stimulation of physical performance, the timing of fatigue onset, and the development of overtraining syndrome among students – hereafter referred to as practitioners of martial arts and combat sports – remain underexplored. This issue encompasses both pharmacological support during training cycles and, critically, during competitive periods. A lack of timely diagnosis of overtraining and performance decline under eccentric physical loads, including in martial arts and particularly in ju-jutsu, frequently results in reduced motivation, deteriorating health, and lower levels of physical and functional fitness. Collectively, these factors compromise the efficiency of training processes and limit competitive outcomes [1].

The development of physical performance and the design of sequential, goal-oriented training interventions – both in Olympic sports broadly and in martial arts and combat sports specifically – constitute a central challenge integrating multiple aspects of athletic and professional preparation. This is not only relevant for athletes but also for personnel in rapid response units, law enforcement, special services, and personal protection, for whom accelerated recovery following physical exertion is essential. Addressing the challenges of optimizing training load regimens and creating favorable conditions for specific adaptation and recovery can be achieved through two main strategies: 1. enhancing the planning and structure of the educational and training process, and 2. the targeted application of non-training methods and aids. Optimal harmonization of the training process, in this context, arises from the integration of pedagogical interventions with rational pharmacological strategies designed to stimulate performance and expedite recovery.

In practice, recovery strategies that enhance both general and task-specific physical performance while accelerating post-exercise physiological responses are particularly valuable. Their application is critical for improving speed, coordination, and preventing overfatigue [4]. However, the use of certain ergogenic or restorative agents without specific justification – or their inappropriate combination – can induce additional iatrogenic (drug-induced) stress on key physiological systems that limit performance capacity, potentially diminishing their contribution to the development of ergogenic potential [7]. Therefore, a clear understanding of the mechanisms underlying recovery and performance-enhancing agents, combined with evidence-based, rational integration into structured training protocols, is essential for achieving high performance across various forms of physical activity, including martial arts and combat sports. The significance of this topic underscores *the relevance* of the present study.

The purpose of the work is to form strategic and tactical ways to provide specialists in the field of sports pharmacology and nutrition, the role of the coach in the implementation of modern similar medical and biological technologies.

Research methods: analysis and generalization of data from modern scientific literature, survey of experts, athletes and coaches.

Results. An analysis of literary data and accumulated practical experience indicates that continuous growth of professional skills and achievement of high competitive results by martial artists, as well as from «white to black belt» among those involved in martial arts (beginner students and subsequent masters) occurs in conditions of optimization of intensity and duration of physical activity, against the background of increasing psychological stress. This stress is often associated with states of «dynamic rest» and frequent climate and time zone adaptations [1]. Taking into account the deterioration of the environment caused by human industrial activity and the increase in social tension, it becomes evident that the body of a martial arts or ju-jitsu practitioner, as well as that of a combat sport athlete, functions at or near the limit of human evolutionary and ontogenetically determined reserves. The simultaneous or sequential action of multiple stress factors leads to an amplification of their mutually negative effects on the body.

In response to exposure to adverse professional and environmental factors of certain doses, intensities, durations, and disruptions of circadian rhythms, states of maximal stress on adaptive mechanisms may develop, accompanied by reversible, and sometimes irreversible, maladaptation phenomena [4]. Based on the structural-functional unity of compensatory and adaptive processes, it can be assumed that in response to extreme stimuli, combat sport athletes and martial arts practitioners experience a state characterized by a shift from the maximum allowable tension of compensatory reactions – which maintain homeostasis – towards maladaptation [1; 4; 18]. The prevention of this phenomenon requires the introduction of pharmacological support within the training process. Under these conditions, the development of an algorithm and systemic principles for the application of pharmacological and nutritional (supplementation) methods and agents aimed at correcting extreme states in combat sports and martial arts practitioners is an important challenge for sports science – including medicine, biochemistry, pharmacology, and nutrition [5]. The medical-biological aspect of recovery and the enhancement of physical performance should be considered in two interconnected directions: 1) recovery of combat sports athletes and martial arts students during the training process; 2) recovery of performance capacity following illness, injury, or overexertion – i.e., actual medical rehabilitation [12]. Of these two directions, only the first is addressed in this article, i.e., pharmacological and nutritional correction.

Methods of such interventions in humans under conditions of intense «action-inactivity», or constant anticipation or involvement in resolving conflict situations, aimed at preserving the health of combat sports athletes and martial arts masters, should be based, first, on the use of WADA-permitted (i.e., non-toxic) substances in the form of drugs and specialized dietary supplements (sport supplements). These support the acceleration of recovery processes and the stimulation of physical performance. The methodology employed must take into account the current scientific knowledge base regarding increased antioxidant protection, reduced severity of endotoxemia syndrome, accelerated neovascularization (physiological angiogenesis) and erythropoiesis, improved metabolic support of muscle activity – including cardiac contractile function through enhanced cardiomyocyte metabolism – and optimized functioning of the central nervous system, among others [3; 7; 15].

Results from numerous studies indicate that the effects of most methods used to maintain muscle activity in martial arts and combat sports are realized through the activation of both specific and non-specific mechanisms of recovery and stimulation of performance, particularly general and specialized capacities [5; 8; 21]. In turn, through the application of pharmacological and nutritional agents classified as indirect ergogenic aids, it is possible to significantly accelerate post-exercise recovery processes, increase strength, speed, coordination abilities, and other general and specialized motor skills, as well as enhance concentration, decision-making time, and other mental characteristics (improvement of psychophysiological parameters). Thus, one of the key systemic principles of sports pharmacology and nutrition is the support and mediated targeted influence on improving performance indicators and motor activity results through the optimization of a significant number of homeostatic links that determine the professional qualities of those engaged in combat sports and martial arts, while preserving their health status and quality of life [6].

Considering the mechanisms of pharmacological and nutritional influence on physiological and biochemical processes occurring in the body, non-prohibited ergogenic and restorative agents

can be divided into the following groups: energy-generating substances and direct macroergs; adaptogens and immunomodulators (primarily through effects on the human microbiome and the «gut-brain axis»); vitamins and coenzymes; antioxidants; agents regulating electrolyte balance in the body; substances affecting blood circulation and blood rheological properties; neurotropic drugs (central nervous system mediators and blockers, regulators of excitation and inhibition processes); drugs enhancing protein synthesis. If necessary, hepatotropic agents, enterosorbents, hematopoiesis stimulators, and others may be added [16].

The use of ergogenic pharmacological and nutritional agents should be based on the implementation of a theoretical concept focused on targeted regulation of metabolism during physical exertion by expanding the «bottlenecks» of metabolic cycles [6]. The individual application of pharmacological agents to enhance the performance of combat sports practitioners and martial artists must be directly based on the consideration of the functional state of the main body systems and the preparation stages within the annual training cycle. It should be noted that the individual selection of drugs and specialized sports dietary supplements necessarily involves the participation of a sports pharmacologist and/or sports nutritionist alongside the coach (or sensei), who formulates the tasks for these specialists at each specific stage of preparing combat sports athletes and martial arts masters in general, and ju-jitsu in particular. The selection of an individualized complex of ergogenic and restorative agents for each specific combat athlete and martial arts practitioner should be determined by a range of parameters, including the results of ongoing and dynamic medico-biological studies, among which laboratory diagnostics play an important role as they allow identification of general and specific metabolic links limiting the physical performance of combat athletes [7].

The fundamental principles of pharmacological and nutritional support (generally corresponding to the doctrine of applying nutritive-metabolic support in sports training) [21], both in elite sports and martial arts, are as follows. First, any pharmacological and nutritional interventions aimed at accelerating post-exercise recovery processes and enhancing physical performance are ineffective or minimally effective when improperly prescribed (unjustified dosage for the given training period, administration regimen, etc.), as well as in the absence of adequate dosing of training loads based on the results of medico-pedagogical examination of ju-jitsu practitioners during long-term adaptation, and proper therapeutic-pedagogical supervision. Second, the acceleration of post-exercise recovery processes should primarily be achieved through (including pharmacocorrective) creation of optimal conditions for their natural progression [10]. Third, when prescribing pharmacological agents and specialized dietary supplements in combat sports and martial arts, it is essential to clearly understand the purpose of their use, the main mechanisms of action (and based on this, the direction of their effect on the efficiency of the training process), as well as contraindications, possible complications, and outcomes of cross-interactions. Finally, fourth, when using nutritive-metabolic support programs in combat athletes and martial arts practitioners to stimulate physical performance and accelerate post-exercise recovery, it is necessary to consider their immediate, delayed, and cumulative effects; differential influence on such physical performance parameters as power, capacity, economy, mobilization, and realization; the mechanism of predominant energy supply for the specific type of work, among others [14].

Our analysis of physiological and homeostatic mechanisms underlying the formation of adaptive capacities allows us to identify the main directions for their correction in the course of further professional activity of combat athletes and practitioners of Eastern martial arts. Prevention of the development or elimination of major nonspecific symptoms of maladaptation includes correction of deficits in the functional reserves of neuroendocrine regulation, energy imbalance, improvement of the structural-functional state of cellular and subcellular membranes, and antigen-structural homeostasis. During such interventions, it is essential to consider not only the mechanisms of their influence but also the time reserve sufficient for implementing these measures and resources, as well as the stage and period of preparation within the annual training cycle, the type of martial art practiced, the mastery level and sports qualification in combat sports, and the gender-age characteristics of the athletes [6; 16]. Unfortunately, today the evaluation of the effectiveness of extratraining ergogenic and restorative means is mainly

performed using pedagogical methods focused on assessing the effectiveness parameters of training and professional activity. Although these methods realistically reflect the influence of the factor at the whole-organism level in combat sports and martial arts, they barely allow managing the intensity, volume, direction, and other individual characteristics of a particular extratraining agent. Therefore, when assessing the efficacy of pharmacological agents on athletes exposed to intensive eccentric loads, modern methodological approaches should also be employed, based on the determination of biochemical, immunoenzymatic, immunological, hematological, and other parameters of organism homeostasis under professional training conditions. This hypothesis we propose is related to the fact that any influence on the organism of a combat athlete or martial arts student primarily causes shifts at the subcellular level, which subsequently manifest in these reactions and functional indicators of individual physiological systems of the body that form the response to the stimulus regardless of its origin or intensity. Regarding martial arts, considering the specificity of motor and mental actions of combat athletes and martial arts students aged 18 and over, for example, in the ju-jitsu school [2], the use of agents such as proteins and amino acids that help maintain the necessary volume and structure of muscle fibers, creatine to increase power, endurance and improve load tolerance, as well as β -hydroxy- β -methylbutyrate (HMB), responsible for converting fat mass into muscle, is primarily necessary. To accelerate post-exercise recovery, which is absolutely necessary in combat sports and martial arts in general and ju-jitsu in particular due to the eccentric nature of locomotion, the use of detoxifiers based, for example, on malic and citric acids (citrulline malate) or arginine, possessing powerful detoxifying action, and ornithine (Hepatrin Detox, L-arginine-L-ornithine, L-ornithine-L-aspartate, Hepa-Merz) is fully justified. To support the function of neutralizing toxic metabolites accumulated during training sessions, primarily ammonia [17], hepatoprotection (from Latin *hepar* – liver and *protecto* – to protect), implemented by using herbal remedies based on milk thistle (Karsil, Hepabene), a plant complex including *Andrographis paniculata*, *Picrorhiza kurroa*, *Eclipta alba*, *Phyllanthus niruri* (Adliv forte), extracts of capers, chicory, and nightshade (Liv-52), which positively affect not only liver function but also have antioxidant, choleric, capillary-strengthening, and diuretic effects [9], is logical. It is known that hyperammonemia (i.e., excessive ammonia accumulation), developing during physical exertion of varying intensity and direction, causes negative shifts in central nervous system functioning in the form of motor disorders, ataxia, and stupor. It is assumed that this may be one of the key central mechanisms of fatigue development, especially under eccentric loads combined with high-level psychophysiological stress, which is typical for combat athletes and martial arts practitioners [17]. Therefore, eliminating excess ammonia from blood serum is positive for forming the ergogenic characteristics of athletes.

From the perspective of optimizing individual psychophysiological characteristics during the study of combat sports and martial arts, special supplements based on Ginkgo biloba, red ginseng, Schizandra chinensis, Eleutherococcus senticosus, and other medicinal plants with adaptogenic properties can be used [19]. After assessing the severity of psychophysiological stress, depending on the results, energizing agents (Enerion, Glycine, Phenotropil; agents containing caffeine in allowed dosages, administered in short courses during training phases or while performing specific professional tasks) [20] or, conversely, sedative agents (based on mint, lemon balm, passionflower, as well as Vita-melatonin at a daily dose of 5 to 10 mg) [11; 13] may be appropriate.

From our perspective, to improve the quality of training in eccentric locomotions such as combat sports and martial arts, characterized by multifaceted metabolic and psychophysiological adjustments, it is necessary, firstly, to increase the frequency of laboratory monitoring, and secondly, to create organizational prerequisites for the integration of specialists such as sports pharmacologists and sports nutritionists into teams (national teams, federations, clubs) of combat athletes and martial arts practitioners. Prospects for further research lie in improving biomedical research and enhancing the individualization of nutraceutical-metabolic support programs for those practicing combat sports and martial arts, which will be especially effective within the club system.

Conclusions. In view of the above, firstly, it is advisable to select the primary metabolic shift that is inherent in any extratraining intervention, on which all subsequent changes in the body are based. Secondly, the modern methodological basis for evaluating the effectiveness of such interventions

using pharmacological and nutraceutical substances must also take into account subtle, species-specific metabolic reactions to individual types of extratraining factors. Combined with changes in pedagogical indicators, such an approach will provide a comprehensive understanding of the appropriateness, validity, and effectiveness of using ergogenic and restorative agents.

Regarding the use of a complex of permitted nutraceutical-metabolic support agents in combat sports and martial arts, as with any other type of physical activity, it is necessary to proceed from the main mechanism of energy supply, anthropometric and bioimpedance data, the nature of locomotion characteristic of a particular type of combat sport or self-defense technique or special operation, as well as individual psychophysiological characteristics.

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НАУКОВЕ ОБҐРУНТУВАННЯ ЗАСТОСУВАННЯ ВІДНОВЛЮВАЛЬНИХ ТА ЕРГОГЕННИХ СТРАТЕГІЙ У БОЙОВИХ МИСТЕЦТВАХ ТА ЄДИНОБОРСТВАХ

Актуальність проблеми. Використання незаборонених фармакологічних і нутриціологічних засобів із ергогенними та відновлювальними векторами дії повинно ґрунтуватися на чіткому розумінні механізмів їхнього впливу на метаболічні функції, що зумовлюють стимуляцію фізичної працездатності, а також на процеси, які це обмежують. Обґрунтоване застосування таких засобів відповідно до їхніх біохімічних та фізіологічних ефектів є ключовим

для ефективного застосування їх із метою зростання власного ергогенного потенціалу та покращення функціонального стану організму представників бойових мистецтв і єдиноборств. **Мета дослідження** – визначити стратегічні та тактичні підходи до забезпечення фахівців зі спортивної фармакології та харчування, а також тренерів сучасними медико-біологічними технологіями для оптимізації фізичної працездатності та відновлення. **Методи дослідження:** аналіз та узагальнення даних сучасної наукової літератури, а також опитування експертів, спортсменів і тренерів.

Результати. Бойові мистецтва, визнані у світі як засіб розвитку моторних навичок та ефективна форма самозахисту, потребують системного застосування ергогенних та відновлювальних засобів для підтримки здоров'я, забезпечення високої якості життя та оптимізації спортивної майстерності. Єдиноборства значною мірою зумовлені східними бойовими традиціями, створюють значні фізіологічні та психоемоційні навантаження через складність технік, переважання ексцентричних навантажень та високий рівень стресу, що зумовлює необхідність цільової фармакологічної та нутриційної підтримки. Ці аспекти підкреслюють критичну важливість структурованої оцінки та впровадження таких утручань. Первинним кроком є визначення ключового метаболічного зсуву, властивого будь-якому позатренувальному фармакологічному або нутрицевтичному втручанню, оскільки саме цей зсув формує основу подальших фізіологічних адаптацій. Сучасна методологічна база оцінки ефективності таких утручань повинна враховувати тонкі видоспецифічні метаболічні реакції на різні категорії позатренувальних стимулів. Інтеграція цього підходу з педагогічними показниками ефективності дає змогу здійснити всебічну та доказово обґрунтовану оцінку доцільності, валідності та загальної ефективності ергогенних і відновлювальних стратегій у бойових мистецтвах і єдиноборствах.

Ключові слова: бойові мистецтва, єдиноборства, дзю-дзюцу, постнавантажувальне відновлення, фізична працездатність, ергогенні засоби, метаболізм.

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