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Publishing House Education and Science (Prague, Czech Republic)
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Public organization "Association of Scientists
of Ukraine" (Kyiv, Ukraine)

Cross-Disciplinary Studies in Science, Innovation and Social Development

Volume XX

Praha, České republika 2026

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Рекомендовано до друку Вченою радою Київського університету авіаційних та інформаційних технологій (протокол № 18/2026 від 12 вересня 2026 р.)

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У двадцятому випуску колективної монографії представлено міждисциплінарні дослідження з права, публічного управління, штучного інтелекту та комп'ютерного бачення, педагогіки, фізичного виховання і спорту, а також військової освіти. Розглянуто трансформацію правової держави в умовах глобалізації, межі застосування штучного інтелекту у поліцейському прийнятті рішень і гарантії прав людини, виявлення змін на аерокосмічних знімках за допомогою сіамської згорткової мережі, предметно-методичну компетентність учителів технологій, сучасні підходи до гідратації спортсменів, мультимедійний супровід уроків фізичної культури та організаційно-педагогічні умови формування громадянської ідентичності майбутніх офіцерів Збройних Сил України.

Монографія адресована науковцям, викладачам, практикам, аспірантам і студентам.

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CHAPTER 4

CONTEMPORARY APPROACHES TO HYDRATION AND WATER BALANCE REGULATION IN ATHLETES DURING EXERCISE

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Water is an essential element of the human organism and is indispensable for its normal functioning. It is involved in numerous physiological and biochemical processes, plays a major role in thermoregulation, creates the necessary medium for metabolic reactions, ensures the transport of nutrients and oxygen to tissues, and

supports the removal of metabolic by-products. Consequently, an adequate supply of fluids is a fundamental prerequisite for sustaining vital processes and maintaining the body's functional capacity. A pronounced lack of water can lead to severe physiological disorders, while the loss of more than 10% of total body water can pose a critical threat to life [2]. For individuals regularly involved in physical activity, maintaining sufficient hydration is particularly significant. The body's water status influences physical performance, endurance, recovery, adaptation to physical and environmental stressors, and the overall functional condition of an athlete. As exercise intensity and duration increase, the body's demand for fluids also rises. Thus, an appropriately organized drinking regimen should be considered an important element of sports training and post-exercise recovery [12].

Physical activity results in increased heat production and intensifies the body's thermoregulatory responses. Sweating represents one of the major physiological pathways through which excess heat is released. When training takes place under conditions of high temperature, increased humidity or inadequate air circulation, considerable quantities of water and electrolytes can be lost. Failure to replace these losses may disrupt water and electrolyte homeostasis and contribute to dehydration, deterioration of physical performance, impaired thermoregulation and, in severe situations, conditions that endanger the athlete's health and life [1]. The issue of adequate fluid intake has been examined in physiological, medical and sports science research. Daily fluid consumption is necessary to support normal metabolism, facilitate the removal of metabolic by-products, and ensure proper functioning of the digestive and excretory systems. When fluid intake is insufficient, the body activates mechanisms designed to conserve water, whereas an adequate supply helps preserve physiological stability and normal body composition [3]. Even minor alterations in body water content can influence the functional condition of an individual engaged in regular physical activity. A decrease in body water of 1% can provoke thirst, whereas a deficit approaching 2% may negatively affect endurance capacity. Studies among athletes indicate that dehydration can impair sports performance, while more

pronounced fluid losses may result in weakness, nausea and reduced functional capacity and, in extreme cases, may produce life-threatening consequences [4].

According to the American College of Sports Medicine, hydration requirements cannot be determined by a single universal daily volume. Individual fluid needs depend on body characteristics, exercise intensity and duration, environmental conditions, sweat rate and other factors. Therefore, athletes should develop an individualized hydration strategy [17]. Maintaining an appropriate water balance is an important physiological condition for preserving working capacity and supporting recovery. Adequate hydration contributes to normal cardiovascular and nervous system function, thermoregulation and metabolic processes. A negative water balance can cause dehydration, cardiovascular strain and deterioration of thermoregulation. Since thirst does not always adequately reflect the actual need for fluid during intensive exercise, it should not be considered the only indicator of hydration status [11]. Water is present in the organism in different structural and functional forms. Free water forms the basis of biological fluids such as blood, lymph, saliva and urine and participates in transportation, circulation and elimination of metabolic products. Hydration water is associated with inorganic ions and macromolecules, including proteins, polysaccharides and nucleic acids, and contributes to maintaining their structural properties. Fixed water is associated with molecular and membrane structures. The distribution of water between these forms' changes depending on the functional state of tissues and metabolic activity [8].

The physiological significance of water is determined by its participation in numerous processes. It serves as a medium for biochemical reactions, facilitates the digestion and absorption of nutrients, transports substances to tissues and promotes the elimination of metabolic products. Water supports cellular structure and function, influences intracellular processes and participates in energy metabolism. In particular, it is involved in ATP hydrolysis, which provides energy for muscular contraction. Water also contributes to acid-base regulation and maintenance of osmotic pressure and participates in the functioning of buffer systems. Water has an important mechanical and protective role. It contributes to the lubrication of joints and other

biological surfaces, reducing friction during movement. For athletes, its thermoregulatory function is especially important. During physical activity, metabolic heat production increases, and sweating together with its subsequent evaporation allows the body to dissipate heat. Consequently, significant fluid loss can reduce thermoregulatory efficiency and increase the risk of overheating [16].

The athlete's hydration strategy should correspond to the duration and intensity of exercise, fluid losses, environmental conditions and individual characteristics. During relatively short and low-intensity exercise, ordinary water is generally sufficient. During prolonged or intensive activity accompanied by considerable sweating, beverages containing carbohydrates and electrolytes may be useful. Solutions containing approximately 2–8% carbohydrates can provide both fluid and an additional energy source during prolonged exercise. Mineral water may provide fluid and electrolytes such as sodium, magnesium and potassium. However, its use should take into account the overall diet and electrolyte losses during exercise. Sodium plays a particularly important role in maintaining extracellular fluid volume and osmotic pressure. During prolonged exercise with heavy sweating, sodium losses may be considerable, although the need for supplementation depends on individual sweat rate, sweat composition, exercise duration and environmental conditions. Potassium and calcium are also important for neuromuscular transmission, muscle contraction and metabolic processes. Nevertheless, increased electrolyte consumption is not always beneficial. The composition and quantity of sports beverages should therefore be selected according to the actual requirements of the athlete. High concentrations of carbohydrates, particularly fructose, may cause gastrointestinal discomfort and diarrhea in susceptible individuals. The body's capacity to absorb fluid is limited. The maximum rate of water absorption is generally considered to be approximately 800 ml per hour. Consequently, rapid consumption of large volumes is not an effective way to compensate for substantial fluid losses. A more appropriate approach is to distribute fluid intake over time and adapt it to the expected rate of loss [14].

Dehydration is a state in which fluid losses exceed intake sufficiently to impair physiological functioning. In sports practice, a reduction of more than 2% of body mass caused by fluid loss is considered an important indicator of dehydration. As dehydration progresses, plasma and circulating blood volume may decrease, sweating may become less effective, and body temperature may rise more rapidly. Redistribution of blood toward the skin increases cardiovascular strain and may reduce blood supply to working muscles and other organs. Dehydration can negatively affect aerobic performance, particularly during prolonged exercise in warm or hot conditions. Endurance activities are especially sensitive to fluid losses because they involve sustained cardiovascular and thermoregulatory demands. Dehydration may also impair concentration, attention, decision-making and other cognitive functions that are important for athletic performance. Another consequence of inadequate hydration is an increased risk of heat exhaustion and exertional heat stroke. Reduced fluid availability limits sweating and increases cardiovascular stress. Simultaneous loss of sodium and other electrolytes may contribute to neuromuscular disturbances, including muscle cramps. Severe dehydration represents a potentially life-threatening condition and requires urgent correction [9].

The characteristics of water balance depend partly on the type of physical activity. Athletes engaged in prolonged aerobic activities, such as long-distance running, experience substantial cardiovascular and thermoregulatory demands. According to the analyzed data, dehydration corresponding to approximately 4–5% of body mass may be accompanied by a 20–30% reduction in performance in predominantly aerobic activities. Short-term activities dominated by anaerobic energy production, including sprinting, weightlifting and powerlifting, may be less immediately affected by moderate dehydration. However, when training volume and duration increase, rest intervals decrease or several sessions are performed during one day, inadequate hydration may negatively affect recovery and overall performance [6]. Thus, hydration recommendations should be adapted to the characteristics of each sport rather than applied uniformly. The timing of fluid intake is also important. During prolonged exercise, especially in a hot environment, regular consumption of

small amounts of fluid may help maintain hydration and reduce gastrointestinal discomfort. In practical terms, athletes may drink every 15–20 minutes when training conditions permit. If fluid consumption during exercise is difficult, greater attention should be paid to hydration before and after training. The restoration of water balance after exercise is an important part of recovery. The required amount of fluid depends on sweat losses and the volume already consumed during exercise. When substantial sweating occurs, fluid replacement should be combined with an adequate intake of electrolytes and nutrients. The goal is not to consume as much fluid as possible but to gradually restore the volume and composition of body fluids [7].

The total amount of water in the organism depends on age, sex and body composition. Muscle tissue contains approximately 72% water, whereas bone contains about 22%. Total body water in adults is commonly within the range of 50–70% of body mass. Children generally have a higher proportion of body water than older adults. Differences between men and women are associated largely with body composition; women generally have a higher proportion of adipose tissue and approximately 10% less body water than men. Body water is distributed between intracellular and extracellular compartments. Approximately 62% of total body water is located inside cells and about 38% outside them. Intracellular fluid provides the environment for cellular metabolism, while extracellular fluid supports circulation and transport. Maintaining an appropriate relationship between these compartments is essential for normal physiological functioning. Water continuously enters the body through drinking and food and leaves through urine, sweat, respiration and feces. Under normal conditions, intake and losses are approximately balanced. During intensive exercise, especially in hot conditions, fluid losses may increase considerably and exceed ordinary replacement. Water balance is regulated by complex neurohumoral mechanisms, with the kidneys playing a central role in adjusting water excretion. Nevertheless, athletes should not rely exclusively on thirst during prolonged exercise because it may not appear until a significant fluid deficit has already developed [5].

For this reason, hydration should be planned according to the characteristics of each training session. During prolonged exercise in elevated temperatures, athletes should determine in advance how much fluid can be consumed during activity. Regular intake in small portions is preferable to consuming a large amount at once. Individual sweat rate can be estimated by comparing body mass before and after exercise while considering fluid intake and urine production. This makes it possible to develop a more individualized hydration strategy. Fluid replacement should correspond as closely as possible to actual losses. Both insufficient and excessive consumption can create problems. Drinking substantially less than the amount lost through sweating leads to dehydration. Conversely, excessive consumption of plain water over a short period can reduce blood sodium concentration and increase the risk of exercise-associated hyponatremia. Therefore, the objective should be controlled restoration of fluid and electrolyte balance [15]. Individual regulation of water balance should consider body mass, age, sex, body composition, physical fitness and sweat rate, as well as the type, intensity and duration of exercise. Environmental temperature, humidity, solar radiation, ventilation, clothing and access to drinking water should also be taken into account. Athletes participating in the same sport may have substantially different sweat rates; therefore, generalized recommendations should serve only as a basis for individual adjustment.

An important aspect of hydration management is the athlete's ability to adapt fluid intake to changes in training conditions. The same exercise performed at different temperatures, humidity levels or training intensities may result in substantially different sweat losses. Therefore, recommendations based only on exercise duration are insufficient for accurate regulation of water balance. Individual monitoring makes it possible to identify the athlete's typical response to physical load and to determine periods when additional fluid intake is necessary. Particular attention should be paid to athletes who participate in several training sessions during the day, since incomplete restoration of fluid and electrolyte losses after the first session may lead to a cumulative deficit. Such a deficit can impair subsequent performance, increase perceived exertion and slow recovery. Regular assessment of

hydration status is therefore useful not only during competitions but also as part of everyday training practice.

An effective hydration strategy also requires regular evaluation of the athlete's response to fluid intake. Changes in body mass, thirst, urine characteristics and subjective well-being can provide useful information for adjusting the drinking regimen. Such observations should be interpreted together with training intensity and environmental conditions to ensure that fluid replacement remains appropriate to individual needs.

Another important consideration is the relationship between hydration and nutritional recovery. Water is required for the transport and utilization of nutrients, while adequate electrolyte availability supports neuromuscular function and restoration of physiological systems after exercise. Consequently, fluid replacement should be considered together with the athlete's overall recovery strategy rather than as an isolated procedure. Appropriate hydration after training may facilitate the restoration of circulating fluid volume and contribute to maintaining normal cardiovascular and metabolic function. For this reason, coaches and athletes should develop hydration habits in advance and incorporate them into the general structure of training, recovery and preparation for competition [13].

The most appropriate hydration strategy is one that allows the athlete to begin exercise adequately hydrated, limits excessive fluid loss during prolonged activity and restores the deficit afterward. Signs of dehydration and overheating, including pronounced thirst, dry mouth, headache, weakness, dizziness, unusual fatigue, reduced sweating and impaired coordination, should be monitored. Severe symptoms require cessation of exercise and appropriate medical assessment. From the standpoint of sports pedagogy, athletes should be encouraged to monitor their hydration status independently. Recording body mass before and after training, approximate fluid intake, exercise duration, environmental conditions and subjective symptoms can help identify individual patterns of fluid loss. Such monitoring promotes responsible self-control and allows drinking behavior to be adjusted according to actual physiological needs. A practical self-regulation system may

include assessment of the forthcoming training conditions, determination of exercise duration and intensity, estimation of expected fluid losses, planning of fluid intake, monitoring during exercise and evaluation of body mass and well-being afterward. The information obtained can then be used to modify the hydration strategy for subsequent training sessions. It is also useful to periodically compare several training sessions conducted under different environmental conditions, because individual sweat losses may change substantially with temperature, humidity, workload and clothing. Such comparison allows athletes and coaches to distinguish stable individual characteristics from situational changes and to improve the accuracy of hydration planning [10].

Such an individualized approach is particularly relevant for endurance athletes and those who train in hot conditions, but it can also be applied in team sports, martial arts and other disciplines involving substantial sweating. Hydration should be practiced during training so that the athlete has an established strategy before competition. It is important to distinguish between maintaining water balance and uncontrolled consumption of large amounts of water. Excessive hydration does not necessarily improve physical performance and may disturb electrolyte balance. Therefore, moderation and correspondence between fluid intake and actual losses should remain the central principles of hydration. The analysis of specialized literature shows that water balance is a dynamic physiological state closely associated with circulation, thermoregulation, metabolism, neuromuscular function and recovery. During prolonged or intensive exercise, physiological mechanisms alone may be insufficient to compensate for rapid fluid losses, making planned fluid intake an important component of maintaining functional stability [18].

Thus, a rational drinking regimen should be based on adequacy, regularity, individualization, consideration of environmental conditions and correspondence between intake and losses. The athlete should avoid both prolonged fluid restriction and excessive consumption. Monitoring body mass and individual sweat losses can provide useful information for determining appropriate fluid intake. The restoration of water balance after exercise should be considered an integral component of

recovery. When considerable fluid losses occur, they should be gradually compensated, with appropriate attention to electrolyte intake. In cases of unusually large losses or severe symptoms, professional medical assessment may be necessary. On the basis of the analysis of specialized scientific and methodological literature, it can be concluded that water is an essential component of the organism and participates in practically all major physiological processes. Its role becomes particularly important during physical activity because exercise increases heat production, sweating, cardiovascular demands and the need for effective thermoregulation. A significant fluid deficit can negatively influence physical performance, endurance, cognitive functioning, cardiovascular activity and recovery. The effects of dehydration depend on the type, intensity and duration of exercise, environmental conditions, individual sweat rate, body composition and the athlete's level of preparedness. Prolonged aerobic activity is generally more sensitive to fluid losses than short-duration anaerobic exercise, although cumulative fluid deficits can negatively influence recovery in all sports.

Individualized regulation of water balance is therefore essential. There is no single fluid intake volume that is equally appropriate for every athlete. Hydration should be planned according to individual characteristics, exercise demands and environmental conditions. Timely restoration of fluid losses is an important condition for maintaining working capacity and supporting recovery. For short and relatively low-intensity exercise, ordinary water is generally sufficient. During prolonged and intensive activity accompanied by substantial sweating, beverages containing appropriate amounts of carbohydrates and electrolytes may be useful. At the same time, excessive fluid and electrolyte intake should be avoided. Adequate hydration supports thermoregulation, cardiovascular function, metabolic processes and neuromuscular performance, whereas dehydration increases physiological stress and may reduce physical and cognitive performance. The development of methods for independent regulation of water balance among athletes is an important practical task. Such methods should include monitoring body mass before and after exercise, assessment of individual sweat losses, consideration of environmental conditions and

planning fluid intake before, during and after training. The use of self-monitoring can become an effective component of health-preserving sports training and contribute to the formation of responsible hydration behavior.

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To chapter 4

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