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The impact of cannabis on endurance and performance of athletes - risks and benefits - a literature review

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Abstract

Introduction and Objective. Cannabis, particularly its active compounds THC (tetrahydrocannabinol) and CBD (cannabidiol), has gained attention in the sports community for its potential therapeutic benefits. Researchers are exploring its use in managing pain, reducing inflammation, enhancing recovery, and alleviating anxiety, making it appealing for treating both acute injuries and chronic conditions in athletes. While CBD is considered safe, THC can impair cognitive functions, potentially affecting performance and increasing the risk of injury. Unlike THC, CBD is not prohibited by the World Anti-Doping Agency (WADA) and is well-tolerated in humans.

Methods. A literature review was conducted using PubMed and Google Scholar, searching terms like "CBD", "THC", "cannabinoids", "physical activity", and "medical marihuana". Articles from the last five years were prioritized.

Brief description of the State of Knowledge. Cannabinoids interact with the body's endocannabinoid system (ECS) and are classified into phytocannabinoids (from cannabis), endocannabinoids (produced by the body), and synthetic cannabinoids (man-made). The two

most studied phytocannabinoids are THC, which is psychoactive, and CBD, known for therapeutic benefits like anxiety reduction without intoxication. THC activates both CB1 receptors (in the brain) and CB2 receptors (in immune cells), while CBD modulates these receptors indirectly. Cannabinoids show potential in managing chronic pain, inflammation, and neurological conditions, with some studies suggesting they could replace opioids for pain relief. They may help in injury recovery among athletes.

Conclusions. The consumption of CBD and THC offer both benefits and risks. However, there is insufficient evidence on the direct impact of cannabis use on athletes beyond its role in pain management and recovery. Further research is needed to provide stronger evidence on their effects in sports.

Keywords: CBD; THC; cannabinoids; cannabis; physical activity; medical marihuana

Introduction and Objective.

The medical use of cannabis has been supported by recent scientific discoveries of the ubiquitous endogenous cannabinoid system (ECS) and its component receptors, ligands, and functional role in a wide range of physiological processes [1]. In recent years, there has been a significant rise in the number of clinical trials exploring the potential effectiveness of medicinal cannabinoids, particularly for the symptomatic treatment of chronic pain [2]. Cannabinoids, which include Δ9-tetrahydrocannabinol (THC) and cannabidiol (CBD), may help athletes in recovery. It is becoming more prevalent in various sports and competition levels [3]. Unlike THC, CBD is no longer prohibited by the World Anti-Doping Agency (WADA) and is generally considered safe and well-tolerated in humans [4]. In contrast to recreational use, medical cannabis therapy aims to enhance or modulate the body's extensive endocannabinoid system (ECS)—a complex, interactive, and crucial regulatory network responsible for maintaining homeostasis. The ECS plays a key role in the modulation of pain and inflammation and is traditionally understood as the system that helps the body "relax, eat, sleep, forget, and protect [5]. Certain cannabinoids are used in clinical settings to treat chronic pain, especially pain related to cancer and multiple sclerosis. They are also employed to stimulate appetite and reduce nausea in HIV/AIDS and cancer patients, as well as to manage spasticity in individuals with multiple sclerosis and epilepsy [6]. The aim of this review is to evaluate the existing literature on the effects of whole cannabis, THC, and CBD on athletic performance and recovery. Specifically, our study focuses on the two primary cannabinoids—

Δ9-tetrahydrocannabinol and cannabidiol—and examines how these compounds interact with the body's endocannabinoid system (ECS).

Methods

A literature review was conducted using PubMed and Google Scholar with search terms like "CBD", "THC", "cannabinoids", "physical activity", "medical marijuana", and related variations. Articles published within the last five years were prioritized.

State of knowledge

Overview of cannabis and its components. Cannabinoids can be classified into three groups according to their source of production: phytocannabinoids, endocannabinoids, and synthetic cannabinoids.

Phytocannabinoids and synthetic cannabinoids. Synthetic cannabinoids (SC) represent a diverse set of compounds engineered to interact with the endogenous cannabinoid system or to explore their potential therapeutic properties. These substances are often developed for research purposes or as candidates for medical treatments [7]. Phytocannabinoids are a group of naturally occurring compounds derived from the *Cannabis* plant. They are recognized for their potential pharmacological activities and medicinal applications. These compounds have garnered significant attention due to their diverse effects on the human body [8].

The most well-known phytocannabinoids are THC (tetrahydrocannabinol) and CBD (cannabidiol), which interact with the body's endocannabinoid system to produce various effects. These two compounds share strikingly similar chemical structures but produce vastly different effects in the brain. While THC is psychoactive and produces a "high" by binding to specific receptors, CBD has anxiolytic and antipsychotic properties without causing intoxication [9].

TABLE 1. Comparison of CBD and THC.

Characteristic	CBD (Cannabidiol)	THC (Tetrahydrocannabinol)
Psychotropic Effects	Non-psychoactive; does not induce a "high" or euphoria [10].	Psychoactive; induces feelings of euphoria, altered perception, and potential anxiety [11].
Side Effects	The use of CBD does not adversely affect psychological and psychomotor functions, gastrointestinal transit, food intake, or cause toxicity in nontransformed cells [12]. Animal studies have shown that CBD can cause side effects such as alterations in cell viability, reduced fertilization capacity, and inhibition of hepatic drug metabolism and drug transporters [12].	Can cause dysphoria, hallucinations, and paranoia sedation, confusion, headache, dry mouth, euphoria, and hypotension [13].
Interaction with Other Compounds	Can enhance the effects of other cannabinoids and has a potential for interaction with pharmaceutical drugs [12].	Can interact with alcohol, sedatives, and other drugs; may enhance or alter their effects [14].
Use in Medicine	Investigated for use in treating a wide range of conditions such as depression, anxiety, post-traumatic stress disorder, Alzheimer's disease and pain [15].	Commonly used in medical cannabis for pain management, muscle spasticity, and nausea in cancer patients [16].

Endocannabinoids. Endocannabinoids are naturally produced by the human body. They are lipid-based neurotransmitters that bind to cannabinoid receptors in the brain and throughout the body. The two main endocannabinoids are:

- anandamide
- 2-AG (2-arachidonoylglycerol)

They play a key role in mediating retrograde signaling, transmitting messages from postsynaptic neurons back to presynaptic ones [17].
It regulates mood, appetite, pain sensation, and other physiological processes [18]. The endocannabinoid system (ECS) is an extensive neuromodulatory network that plays a crucial role in the development of the central nervous system and in regulating various cognitive and physiological processes. It consists of endogenous cannabinoids, cannabinoid receptors, and the enzymes that synthesize and break down endocannabinoids [19].

Mechanism of action, pharmacokinetics. The mechanism of action of these substances in the human body is also relevant. Currently, two types of cannabinoid receptors have been identified within the endocannabinoid system (ECS): the CB1 receptor, located primarily in the central nervous system, and the CB2 receptor, which is found on immune cells [20]. CB1 receptors are present in both central and peripheral neurons, and their activation helps suppress nociceptive sensitization, reducing the perception of pain. In contrast, activation of CB2 receptors alters the release of pro-inflammatory cytokines from immune cells and modulates the migration of these cells, ultimately reducing the inflammatory response [20]. THC interacts with both CB_1 and CB_2 receptors as a partial agonist with less efficacy than endogenous cannabinoids [20]. CBD interacts with CB_1 receptors as an allosteric modulator, binding to an alternative site and negatively affecting the efficacy and potency of agonists, such as THC. CBD is recognized to also modulate other receptors, such as serotonin receptor or μ- and δ-opioid receptors [21].

TABLE 2: Mechanisms of action: how cannabis affects the body.

BODY SYSTEM	**EFFECT OF THC**
Cardiovascular system	- Increased heart rate (tachycardia) - Possible decrease in blood pressure (hypotension) - Decreased cardiac contractility chronically - elevated oxidative stress [22]

Neurological System	- Psychoactive effects, including euphoria, altered perception, and cognitive impairment - Analgesic (pain-relieving) effects - Potential for short-term memory impairment [23]
Respiratory System	- Bronchodilation (temporary widening of airways) - Chronic use (via smoking) may lead to respiratory issues such as bronchitis, coughing, or lung irritation [24]
Endocrine System	- Possible alteration of hormone levels (e.g., reduced testosterone levels) - May influence appetite (increased hunger) [25]
Immune System	- Modulates immune response, potentially reducing inflammation [26]
Musculoskeletal System	- Pain relief (analgesic effect) - Potential muscle relaxation - May reduce inflammation [27,28]
Gastrointestinal System	- Stimulation of appetite - Anti-nausea and anti-vomiting effects - Potential slower digestion [29,30]
Psychological Effects	- Induces feelings of euphoria or relaxation - May cause anxiety, paranoia, or altered mood in some users - Potential therapeutic effects for conditions

	like PTSD, depression, and anxiety [31,32]
Skin and Dermatological	- Cannabinoid receptors in the skin may influence sebaceous gland activity, possibly affecting conditions like acne [33] - Anti-inflammatory effects may help with conditions like psoriasis or eczema [34]

Considerations for therapeutic use in athletes

Acute pain. Research on the use of cannabinoids for treating acute pain in humans remains limited. Current knowledge largely stems from small studies, which provide only modest evidence regarding the effectiveness of this treatment. One small, randomized, double-blind, placebo-controlled crossover study with 15 healthy participants examined pain response in a capsaicin-induced intradermal pain model using cannabis with varying doses of THC [35]. The results showed no change in pain perception at any dose 5 minutes after administration. However, after 45 minutes, participants reported a significant reduction in pain at the moderate dose, an increase in pain at the higher dose, and no change at the lower dose [35]. Another small, double-blind, randomized crossover study with 18 healthy women, using sunburn and capsaicin-induced pain models, found that oral cannabis extract capsules had no effect on acute pain perception [36].

Chronic pain. The International Association for the Study of Pain (IASP) defines chronic pain as persistent or recurrent pain lasting longer than 3 months [37]. The evidence for cannabinoid therapy in chronic pain seems more robust with studies showing pain reduction.The National Academies of Sciences, Engineering, and Medicine concluded that there is conclusive or substantial evidence supporting the effectiveness of cannabis or cannabinoids in the treatment of chronic pain in adults [28]. Opioids have been the primary treatment for managing intractable chronic pain for a considerable period of time. However, the negative side effects associated with their use, as well as the rise in mortality rates resulting from overdoses, have raised significant concerns. As a result, cannabis extracts and synthetic derivatives are gradually replacing opioids in the treatment of various conditions involving chronic pain and inflammation [38]. Some studies have suggested that opioids are

associated with similar improvements in pain management and physical functioning when compared to synthetic cannabinoids [39]. In order to reduce the amount of opioids used in therapy it is possible to combine opiods and cannabinoids resulting in an opioid-sparing effect [40]. In a study by Boehnke et al. 185 chronic pain patients using opioids found a self-reported 64% reduction in opioid use with medical cannabis therapy. Participants using medical cannabis alongside chronic opioid treatment also reported a 45% improvement in quality of life and a reduction in opioid-related side effects [41]. In a systematic review by Whiting et al., which included 28 studies on chronic pain treated with cannabis preparations administered via various routes. The review encompassed patients with chronic pain stemming from neuropathic, inflammatory, central, musculoskeletal, and rheumatologic causes. Compared to placebo, a greater proportion of patients using cannabinoid-based products experienced at least a 30% reduction in pain scores [42].

Osteoarthritis. Osteoarthritis (OA) is the most common disease of joints. It is a type of degenerative joint disease that results from breakdown of joint cartilage and underlying bone.The OA therapies available are symptomatic, largely targeting pain management rather than disease progression. Cannabinoids help modulate inflammation and reduce joint damage, indicating a potential chondroprotective effect on joints, because both CB1 and CB2 receptors are expressed in cartilage, bone, and synovial tissue [43]. Although osteoarthritis (OA) is commonly associated with the elderly population, who are typically inactive, athletes and younger individuals can also develop this condition. Diagnosis of OA in athletes can be challenging due to their high pain tolerance and desire to quickly return to sports. Therefore, treatment for OA in athletes and young people should be personalized, taking into account the patient's expectations and the length of time they may need to be away from sports activities [44]. Despite the availability of pharmacological treatments for osteoarthritis (OA), an increasing number of individuals are turning to medical cannabis for managing symptoms of OA and reducing their reliance on opioids for pain relief. Although there is limited quality evidence supporting the use of medical cannabis as a replacement for traditional pharmacological treatments for OA, there are observations suggesting that it may offer therapeutic benefits to some patients [45].

Recovery. The most common recovery strategies for training and competition include hydration, nutrition, sleep, rest, stretching, foam rolling, active recovery, self-massage, traditional massage, socializing, wearing compression garments, and practicing mindfulness

[46] The use of CBD or THC has been proposed as potentially beneficial in managing pain, reducing inflammation, and improving sleep, all of which are crucial for the recovery process after exercise [47]. Sleep is essential for both physical and mental well-being, making it vital for athletes to prioritize rest. By addressing sleep disturbances promptly, athletes can enhance their performance and lower the risk of injury. Additionally, sufficient sleep has been shown to improve cognitive function, reaction times, and emotional regulation, underscoring the need for targeted sleep interventions in athletic populations [48]. Many athletes associate sleep quality with recovery and overall sports performance [49]. Furthermore, CBD has been associated with therapeutic improvements in sleep at higher doses, while lower doses may have stimulating effects [50]. While cannabis use is has become more common among athletes participating in high-risk sports, there is currently no direct evidence to suggest that it enhances performance [51]. Although research in this area is limited, it is evident that many individuals are turning to cannabis and are convinced of its positive impact on post-exercise recovery [47].

Anti-inflammatory effects. Engaging in exercise can result in a robust inflammatory response, characterized by the mobilization of leukocytes and an increase in circulating inflammatory mediators produced by immune cells and muscle tissue. Different training protocols have shown both positive and negative effects on immune function and susceptibility to illness. Moderate activity can enhance immune function, while excessive amounts of high-intensity exercise may impair it. Intense and prolonged exercise can lead to higher levels of inflammatory mediators, increasing the risk of injury and chronic inflammation. Specifically, pro-inflammatory cytokines such as IL-6 are elevated after intense exercise, followed by an elevation of IL-10 [52]. Cannabinoids have been shown to act as powerful anti-inflammatory agents within the body. These compounds exert their effects by inducing apoptosis (programmed cell death), inhibiting the proliferation of cells, suppressing the production of pro-inflammatory cytokines, and promoting the activation of T-regulatory cells, which help modulate the immune response [53] Research on neonatal rat cortical microglial cells has demonstrated that exposure to THC leads to a decrease in lipopolysaccharide (LPS)-induced mRNA expression of several important inflammatory cytokines, including IL-1alpha, IL-1beta, IL-6, and TNF-alpha [54] . Among these, IL-6 is a cytokine that plays a crucial role in regulating the alternative activation of macrophages, which are key immune cells involved in the inflammatory process [55]. IL-6 is particularly sensitive to the effects of THC and is involved in the acute-phase response to inflammation

[54]. Given that cannabinoids can suppress IL-6 production, they may help reduce inflammation, which could, in turn, lead to improved tissue recovery following injury. This anti-inflammatory action suggests that cannabinoids could be beneficial in promoting faster and more efficient recovery after physical exertion or injury, supporting the body's healing process in a natural and effective way.

Risks and potential downsides of cannabis use. Medical cannabis differs from recreational cannabis in its chemical composition of THC and cannabidiol (CBD), methods of administration, and overall safety profile. Although cannabis has therapeutic benefits, exposure to high levels of THC—the primary compound responsible for its intoxicating effects—can lead to psychological disturbances and adverse effects on nearly every body system. These include neurological symptoms (such as dizziness, drowsiness, seizures, and even coma), ophthalmological issues (like pupil dilation and red eyes), cardiovascular problems (including tachycardia and high blood pressure), and gastrointestinal issues (such as nausea, vomiting, and increased thirst), primarily linked to recreational use [6].

Conclusion

The use of cannabis, particularly its compounds THC and CBD, in athletes is an emerging area of interest with both potential benefits and risks. CBD has shown anti-inflammatory properties that may reduce muscle soreness and inflammation, while both THC and CBD can potentially improve sleep quality and alleviate pain, aiding in post-exercise recovery. The anti-inflammatory effects of cannabinoids are particularly relevant for athletes, as intense physical activity often triggers inflammation, which can hinder recovery and increase the risk of injury. Furthermore, cannabis-based therapies could serve as an alternative to opioids, which are commonly used to manage chronic pain, offering a safer, non-addictive option for long-term pain management. However, despite these potential benefits, the use of cannabis in sports also presents several risks. High doses of THC can impair cognitive ability, which may negatively affect performance and focus, especially during competition. Additionally, the psychoactive properties of THC can lead to psychological side effects, such as anxiety or altered mood, which may be detrimental for athletes who rely on mental clarity and emotional regulation. In conclusion, while cannabis has the potential to offer therapeutic advantages to athletes, particularly in terms of pain relief, inflammation reduction, and sleep enhancement, its use should be approached cautiously. Further research is essential to better understand the long-term effects of cannabis on athletic performance and health, as well as its safety profile.

Athletes considering cannabis as part of their recovery regimen must weigh the potential therapeutic benefits against the risks, particularly in regard to performance impairment, legal restrictions, and the possibility of adverse side effects.

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Conceptualization: MZ, AN

Methodology: MZA, GB

Software: GB, AN

Check: PN, WP, MZA

Formal analysis: WP, MZ

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