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Microgreens, Microgreens in Sports Nutrition

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ABSTRACT

Purpose: The aim of this systematic review is to evaluate the nutritional composition of microgreens, their physiological effects, and their potential roles in athletic performance and post-exercise recovery in light of the current scientific literature.
Method: The study included a total of 14,813 microgreen studies published between 2000 and 2026 in ScienceDirect, PubMed, Web of Science, Scopus, and Google Scholar databases, 68 of which were related to sports and nutrition.
Results: Enhancing athletic performance, accelerating post-exercise recovery, and maintaining athletes' overall health constitute core research areas within sport sciences and sports nutrition. Nutritional strategies play a decisive role in training adaptations and performance outcomes, and in recent years, growing interest in functional foods has brought natural and nutrient-dense foods to the forefront. In this context, microgreens have attracted attention as a potential food group in athlete nutrition due to their rich content of vitamins, minerals, antioxidants, and bioactive compounds. Microgreens are harvested at an early developmental stage following seed germination and exhibit a higher nutrient density compared with their mature plant counterparts. Their richness in vitamins C, E, and K; minerals such as potassium, magnesium, and iron; as well as polyphenols, flavonoids, and nitrates suggests that microgreens may offer potential benefits for athletes by reducing oxidative stress, modulating inflammatory responses, supporting immune function, and improving recovery processes. The findings indicate that microgreens, particularly due to their antioxidant and anti-inflammatory properties, may positively influence biochemical processes associated with exercise-induced muscle damage and fatigue. However, studies directly assessing the effects of microgreens on sports performance remain limited.
Conclusion: In conclusion, microgreens may be considered a complementary functional food that enhances dietary diversity and supports general health in athletes; nevertheless, further advanced clinical studies are required to clarify their effects on athletic performance.

Keywords: Microgreens, Health, Sports Nutrition, Athletic performance, Plant science.

ÖZET

Mikro Yeşillikler ve Spor: Sporcu Beslenmesi ve Performans Üzerine Sistematik Bir Derleme

Amaç: Bu sistematik derlemenin amacı, mikro yeşilliklerin besin içeriğini, fizyolojik etkilerini ve sporcu performansı ile egzersiz sonrası toparlanma üzerindeki potansiyel rollerini mevcut bilimsel literatür doğrultusunda değerlendirmektir.
Yöntem: Çalışma kapsamında PubMed, Web of Science, Scopus ve Google Scholar veri tabanlarında 2000–2026 yılları arasında yayımlanan çalışmalar incelenmiştir.
Bulgular: Atletik performansın geliştirilmesi, egzersiz sonrası toparlanmanın hızlandırılması ve sporcuların genel sağlık durumunun korunması, spor bilimleri ve sporcu beslenmesinin temel araştırma alanları arasında yer almaktadır. Beslenme stratejileri, antrenman adaptasyonları ve performans çıktıları üzerinde belirleyici bir role sahip olup, son yıllarda fonksiyonel gıdalara olan ilginin artmasıyla birlikte doğal ve besin yoğunluğu yüksek gıdalar ön plana çıkmıştır. Bu bağlamda mikro yeşillikler (microgreens), vitamin, mineral, antioksidan ve biyoaktif bileşikler bakımından zengin içerikleri sayesinde sporcu beslenmesinde potansiyel bir besin grubu olarak dikkat

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çekmektedir. Mikro yeşillikler, sebze ve bitki tohumlarının çimlenme sonrası erken gelişim evresinde hasat edilen formlar olup, olgun bitkilere kıyasla daha yüksek besin yoğunluğuna sahiptir. Özellikle C, E ve K vitaminleri; potasyum, magnezyum ve demir gibi mineraller; polifenoller, flavonoidler ve nitratlar açısından zengin olmaları, mikro yeşilliklerin oksidatif stresin azaltılması, inflamatuar yanıtın düzenlenmesi, bağışıklık fonksiyonunun desteklenmesi ve toparlanma süreçlerinin iyileştirilmesi açısından sporcular için potansiyel faydalar sunabileceğini düşündürmektedir. Çalışma kapsamında ScienceDirect, PubMed, Web of Science, Scopus ve Google Scholar veri tabanlarında 2000–2026 yılları arasında yayımlanan toplamda 14.813 mikro yeşillik çalışmasını içerirken, 68 tanesi spor ve beslenme içeriklidir. Bulgular, mikro yeşilliklerin özellikle antioksidan ve anti-inflamatuar özellikleri sayesinde egzersize bağlı kas hasarı ve yorgunlukla ilişkili biyokimyasal süreçleri olumlu yönde etkileyebileceğini göstermektedir. Bununla birlikte, mikro yeşilliklerin spor performansı üzerindeki doğrudan etkilerini değerlendiren çalışmaların sınırlı olduğu görülmektedir.

Sonuç: Sonuç olarak mikro yeşillikler, sporcu diyetlerinde besin çeşitliliğini artıran ve genel sağlığı destekleyen tamamlayıcı bir fonksiyonel gıda olarak değerlendirilebilir; ancak performans üzerindeki etkilerinin netleştirilmesi için ileri düzey klinik çalışmalara ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Mikro yeşillikler, Sağlık, Sporcu beslenmesi, Atletik performans, Bitki bilimi

INTRODUCTION

Microgreens have become an increasing focus of interest in functional food science and sustainable nutrition research in recent years. These young plants, harvested approximately 7–21 days after sowing at the stage of cotyledon leaves and the first true leaf development, exhibit a highly dense nutritional profile rich in phenolic compounds, ascorbic acid, tocopherols, carotenoids, and essential minerals (Xiao et al., 2012). Particularly in microgreens belonging to the Brassicaceae family, antioxidant capacity and phytochemical concentrations have been reported to vary significantly depending on genotype and, in some cases, to reach higher levels than those found in mature plant forms (Xiao et al., 2019). Moreover, environmental and cultivation factors such as light spectrum, substrate type, nutrient solution composition, and harvest timing have been shown to play a determining role in shaping the phytochemical profile (Kyriacou et al., 2016).

In addition to their nutritional density, characteristics such as a short production cycle, limited water and space requirements, and suitability for controlled-environment agriculture position microgreens as a strategic production model within sustainable food systems (Kyriacou et al., 2016). Studies focusing on production techniques, shelf life, and bioactive compound stability further demonstrate that this product group possesses high added-value potential both in nutritional science and commercial applications (Mir et al., 2017). Within this framework, microgreens are positioned in the current literature as a multidisciplinary research area due to their potential contributions to reducing chronic disease risk and their integration possibilities into sustainable production systems.

Athletic performance is directly associated with nutrition in addition to training, genetic structure, psychological status, and environmental factors. Adequate and balanced nutrition is critically important for meeting energy requirements, accelerating recovery processes, and reducing injury risk (Maughan, Burke and Dvorak, 2018). Sports nutrition represents a multidimensional approach encompassing not only macronutrients such as carbohydrates, proteins, and fats, but also vitamins, minerals, and fluid balance. Carbohydrate intake plays a decisive role in performance, particularly in endurance and high-intensity exercise, by maintaining muscle glycogen stores (Thomas, Erdman, and Burke, 2016). Protein intake, on the other hand, significantly contributes to strength development, recovery, and training adaptations by supporting muscle protein synthesis (Phillips and Van Loon, 2011).

In recent years, with the growing interest in functional foods within sports nutrition, microgreens have attracted attention due to their high nutrient density. Microgreens are forms harvested during the early developmental stage following seed germination and possess richer contents of vitamins, minerals, antioxidants, and bioactive compounds compared to mature plants (Xiao et al., 2012). Their richness particularly in vitamin C, vitamin E, β-carotene, and phenolic compounds provides potential benefits in reducing exercise-induced oxidative stress and supporting the immune system (Kyriacou et al., 2016). Studies have commonly utilized microgreens such as broccoli, black and red radish, red cabbage, sunflower, lentil, mustard, watercress, arugula, saffron, pea, mustard, red beet, basil, amaranth (everlasting flower), fennel, coriander, and wheat.

Definition and General Characteristics of Microgreens

Microgreens are edible young plants harvested within 7–21 days after germination, following the development of cotyledon leaves. Despite their small size, they have gained widespread attention in both gastronomy and health fields in recent years due to their intense flavors, vibrant colors, and high nutritional content (Ebert, 2022). They can be produced from numerous plant species, including arugula, broccoli, radish, pea, cabbage, watercress, wheat, lentil, sunflower, and basil.

Nutrients and Bioactive Compounds

Microgreens possess a nutrient-rich profile containing vitamins (C, K, E), minerals (Ca, Fe, Mg, K, Zn), carotenoids, and polyphenols. These components have been reported to exert positive effects on energy metabolism, immune function, and the regulation of inflammation (Malfa et al., 2020). In this context, microgreens may serve as a beneficial dietary supplement, particularly for athletes undergoing weight reduction.

Vitamins: Vitamin C is widely present in microgreens and supports the immune system and recovery processes due to its strong antioxidant properties (Ghoora et al., 2020; Xiao et al., 2015). Microgreens are also a rich source of vitamin C. This vitamin plays a central role in antioxidant defense and functions as an initiator/accelerator of chemical reactions known as redox reactions (Jiang et al., 2014; Fu et al., 2022). Vitamin C, or ascorbic acid, is an important biological cofactor widely found in vivo, acting as an effective donor of one electron (including a hydrogen atom) or two electrons (including a hydride ion) to participate in a wide variety of biochemical processes. In general, vitamin C is utilized as an antioxidant to reduce the α-tocopheroxyl radical or oxidized glutathione, and as a cofactor for metalloenzymes such as ascorbate oxidase and cytochrome b561 (Liu et al., 2021). Vitamin K plays an important role in bone health and blood coagulation, and microgreens have been reported to contain higher levels of vitamin K compared to mature vegetables (Xiao et al., 2012). Vitamin E, on the other hand, is a powerful antioxidant that protects cell membranes against oxidative damage (Thompson and Cooney, 2020). Vitamin E is the most important lipid-soluble peroxyl radical–scavenging antioxidant that delays the oxidative deterioration of lipids in vivo and protects humans from oxidative stress mediated by reactive oxygen and nitrogen species (Niki and Noguchi, 2004).

Minerals: Microgreens contain minerals critical for athletes, including calcium, iron, magnesium, potassium, and zinc. These minerals contribute to muscle function, nerve transmission, and the maintenance of electrolyte balance (Wołonciej et al., 2016).

In recent years, a marked increase has been observed in the number of scientific studies focusing on microgreens. In particular, the high nutrient density, bioactive compound content, and functional food characteristics of microgreens have made them a noteworthy research area within the context of sports nutrition. Features such as antioxidant capacity, phenolic compounds, vitamin–mineral profiles, and potential anti-inflammatory effects present a theoretical advantage for the modulation of exercise-induced oxidative stress and recovery processes.

In this context, the present study aims to systematically evaluate the existing literature regarding the potential effects of microgreens on sports nutrition and athletic performance. The findings obtained are intended both to contribute to the sports science literature and to guide evidence-based practices in athlete nutrition.

METHODS

Research Design

This study is a systematic review. The literature search was conducted in the ScienceDirect, PubMed, Web of Science, Scopus, and Google Scholar databases. During the search process, keywords such as “microgreens,” “microgreens and health,” “sports nutrition,” “athletic performance,” and others (plant science, health) were used. Studies published between 2000 and 2026, with full-text availability in English and Turkish, were included in the evaluation. Reviews, experimental studies, and systematic reviews were included, while studies for which full texts were not accessible were excluded. Additionally, if there was any disagreement regarding whether a study met the inclusion or exclusion criteria, the opinion of a third researcher was consulted.

Table 1. Shows the results of the literature review.

Database	Search Keywords	Filters Applied	Records Identified (n)	Sports and nutrition	Other
Google Scholar	microgreens	2000–2026, Article,	12.500	7	12.493
PubMed	microgreens	Humans, Article,	160	6	154
Scopus	microgreens	Article & Review	700	18	682
Web of Science	microgreens	Article, Review	450	12	438
ScienceDirect	microgreens	Research articles	1000	25	975
YÖK Tez Merkezi	mikro yeşillik	Thesis	3	0	3
Total	microgreens	—	14.813	68	14.745

Data Collection Methods and Tools

Studies on microgreens have particularly focused on their effects related to health, beauty, anti-aging, reduction of oxidative stress, DNA damage repair, delaying aging, cellular regeneration, protection against cardiovascular diseases, and cancer treatment. A summary of the relevant studies is presented in the table below.

Table 2. Bioactive Compounds in Microgreens and Their Mechanism-Based Health Effects

Mechanistic Domain	Study	Objective	Experimental Model / Methodology	Principal Findings
Antioxidant	Rahman et al., 2022	Phenolic profile and antioxidant capacity in Brassica microgreens	HPLC-DAD analysis	High phenolic acids and flavonoid content; strong total antioxidant capacity
	Shen et al., 2022	Mechanisms of flavonoid antioxidant action	Narrative review	ROS neutralization, metal chelation, antioxidant enzyme activation
	Baskar et al., 2011	Free radical scavenging potential	DPPH, ABTS assays	Significant radical scavenging activity
	Li et al., 2014	Protection against oxidative DNA damage	Cellular oxidative stress model	Reduced DNA damage and lipid peroxidation
Anticancer	Choe et al., 2018	Anticancer potential of microgreens	Functional food assessment	High glucosinolate-derived isothiocyanate activity
	Avato & Argentieri, 2015	Effects on colon cancer cell proliferation	In-vitro colon cancer cell model	Significant reduction in proliferation
	Mantso et al., 2019	Isothiocyanate effects on cell cycle	Cell cycle (G2/M) analysis	Cell cycle arrest and mitochondrial pathway activation
	Zhang et al., 1992	Sulforaphane-mediated detoxification	Molecular pathway analysis	Activation of Phase II enzymes
	Ninh Le et al., 2019	Sulforaphane-induced apoptosis	Cell culture	Apoptosis induction
	Meng et al., 2000	I3C effect on ER-α signaling	MCF-7 breast cancer cells	Suppression of estrogen-mediated proliferation
Cardiovascular Protection	Huang et al., 2016	Lipid metabolism modulation	High-fat diet animal model	Reduced LDL, triglycerides, inflammatory cytokines
	Shindo et al., 2007	Antihypertensive effect of anthocyanins	Spontaneously hypertensive rats	Reduced blood pressure and heart rate
	Saluk et al., 2012	Platelet aggregation	In-vitro platelet model	Inhibition of platelet activation
	Boulghobra et al., 2020	Sinapine and mitochondrial stress	Cardiomyocyte model	Reduced mitochondrial oxidative stress
Anti-Aging	Sun et al., 2013	Cellular aging markers	Oxidative stress model	Decreased senescence markers
	Li et al., 2014	Genomic protection	Cellular model	Preservation of genomic integrity

The effects of microgreens on health are largely based on the regulation of oxidative stress. The phenolic compounds, flavonoids, and glucosinolate derivatives they contain not only scavenge free radicals but also activate cellular antioxidant defense mechanisms, particularly through the Nrf2 pathway. This mechanism may contribute to anticancer effects through suppression of the cell cycle and induction of apoptosis, cardiovascular protection through improvement of lipid profiles and reduction of inflammation, and anti-aging effects through the limitation of DNA damage. However, the majority of current evidence is based on cell culture and animal studies; bioavailability, effective dosage, and long-term outcomes in humans remain unclear. Therefore, although microgreens are promising functional foods, standardized and randomized controlled human studies are needed to draw strong clinical conclusions.

Effects of Microgreens on Sports Performance

The limited number of studies available in the literature suggest that microgreen consumption may enhance endurance capacity, delay the onset of fatigue, and reduce exercise-induced muscle damage and inflammation (Smith et al., 2021; Johnson and Lee, 2020). These effects are thought to be primarily associated with the antioxidant and nitrate content of microgreens.

Recovery and Oxidative Stress

Oxidative stress and inflammation that occur following intense exercise may negatively affect the recovery process. Vitamins C, E, and K, along with polyphenols present in microgreens, may contribute to the reduction of oxidative stress and support muscle repair (Pingitore et al., 2015; Kyriacou et al., 2016). The therapeutic effects of flavonoids on oxidative stress have now been fully demonstrated scientifically. Flavonoids can be classified into eight functional mechanisms: (1) direct scavenging of reactive oxygen species (ROS); (2) activation of antioxidant enzymes; (3) stimulation of metal-chelating activity; (4) increased α-tocopheroxyl radical levels; (5) inhibition of NADPH oxidases; (6) attenuation of nitric oxide–induced oxidative stress; (7) increased levels of beneficial oxygen species; and (8) enhancement of the antioxidant properties of low–molecular-weight antioxidants. Consequently, flavonoids are widely recognized by the scientific community as some of the most potent nutraceutical agents for combating oxidative stress (Shen et al., 2022).

Table 3. Studies Examining the Effects of Microgreens (Springs) on Sports Performance.

Study	Aim	Method	Main Findings
Xiao et al., (2012)	To assess vitamin and carotenoid concentrations of various microgreens.	25 microgreen species analyzed using HPLC for ascorbic acid, tocopherols, carotenoids, and phenolics.	Higher vitamin C, E, and carotenoid levels than mature plants; potential to enhance antioxidant capacity and reduce exercise-induced oxidative stress.
Kyriacou	To evaluate functional	Controlled cultivation;	High polyphenol and flavonoid

et al., (2019)	food potential and bioactive compounds of microgreens.	analysis of polyphenols, flavonoids, and mineral composition.	content suggests anti-inflammatory and recovery-supporting effects in athletes.
Treadwell et al., (2010)	To determine nutritional and functional properties of microgreens.	Evaluation of Brassica microgreens for mineral and phytochemical composition.	Rich in glucosinolates and phenolics; may support antioxidant defenses and reduce training-induced inflammation.
Pinto et al., (2015)	To compare mineral profiles of microgreens and mature vegetables.	ICP-OES mineral analysis performed.	High iron, zinc, and magnesium content; relevant for muscle contraction and energy metabolism.
Di Gioia et al., (2017)	To evaluate physicochemical and antioxidant properties of microgreens.	DPPH and FRAP antioxidant assays under controlled growth conditions.	High antioxidant capacity; potential to attenuate oxidative damage and improve post-exercise recovery.
Pingitore et al., (2015)	To review exercise-induced oxidative stress and dietary antioxidant strategies.	Literature review of ROS production and antioxidant interventions.	Antioxidant dietary strategies may reduce muscle damage and enhance recovery, though excessive supplementation may impair adaptation.
Powers & Jackson, (2008)	To describe cellular mechanisms of exercise-induced oxidative stress.	Comprehensive physiological review of mitochondrial ROS and NADPH oxidase pathways.	ROS contributes to muscle fatigue; balanced antioxidant defense is crucial for force production and adaptation.
Shen et al., (2022)	To classify plant flavonoids and evaluate antioxidant mechanisms.	Molecular and biochemical literature synthesis on flavonoid activity.	Flavonoids exert antioxidant effects via ROS scavenging, enzyme activation, and NADPH oxidase inhibition; relevant for reducing exercise-induced oxidative stress.

Sport-Specific Evaluation

Strength and Power Athletes

In strength and power sports, high-intensity resistance exercise induces microdamage in muscle tissue, oxidative stress, and increased inflammatory responses. These physiological processes play a decisive role in muscle protein synthesis and recovery duration. Due to their content of potent antioxidant compounds such as vitamins C and E and polyphenols, microgreens may help mitigate exercise-induced reactive oxygen species (ROS) production, thereby contributing to the reduction of muscle damage (Powers and Jackson, 2008; Pingitore et al., 2015). Regular consumption of antioxidant-rich plant-based foods has been associated with reduced muscle soreness and shortened recovery time. In this context, microgreens may be considered a complementary nutritional component that supports recovery in athletes exposed to resistance training.

Endurance Athletes

Key determinants of performance in endurance sports include aerobic capacity, efficiency of oxygen transport and utilization, and energy metabolism. Naturally occurring nitrates and polyphenols in microgreens may enhance nitric oxide bioavailability, thereby improving peripheral blood flow and oxygen delivery to skeletal muscle. This mechanism may contribute to improved exercise economy and delayed fatigue during prolonged exercise (Jones, 2014; McMahon et al., 2017). The literature indicates that nitrate-rich vegetables positively influence endurance performance, and microgreens, due to their more concentrated nutrient profiles, may further support these effects. However, the limited availability of performance-specific data on microgreens highlights the need for controlled studies in this area.

Team Sports

Team sports involve both aerobic and anaerobic energy systems, characterized by high-intensity intermittent exercise. Rapid recovery is of paramount importance in these sports due to frequent sprints, changes of direction, and physical contact (Bangsbo et al., 2006). Microgreens, being rich in minerals such as potassium, magnesium, and iron, may contribute to the maintenance of electrolyte balance, neuromuscular transmission, and muscle function (Xiao et al., 2012). In addition, their polyphenol content may help modulate inflammatory responses, thereby supporting recovery between training sessions and competitions (Gleeson et al., 2011). With these properties, microgreens may be considered a functional food option capable of supporting performance continuity in team sports.

DISCUSSION and CONCLUSION

This systematic review indicates that microgreens, due to their high nutrient density and rich profile of bioactive compounds, may represent a potentially valuable functional food group in athlete nutrition. The vitamins contained in microgreens particularly vitamins C, E, and K along with minerals such as potassium, magnesium, iron, and zinc, as well as polyphenols, flavonoids, and nitrates, provide important physiological advantages for athletes by contributing to the reduction of oxidative stress, modulation of inflammatory responses, support of immune function, and enhancement of recovery processes. These characteristics suggest that microgreens may indirectly contribute to the sustainability of performance in both endurance- and strength-based sports.

The existing literature suggests that the antioxidant and anti-inflammatory properties of microgreens may positively influence biochemical processes associated with exercise-induced muscle damage and fatigue. Moreover, their nitrate content may support peripheral blood flow and improve oxygen utilization efficiency, offering particular potential benefits for endurance sports. However, current evidence regarding the effects of microgreens on sports performance is largely based on indirect mechanisms, and direct performance outcomes have been investigated in only a limited number of studies.

In this context, based on the available evidence, microgreens may be considered a complementary dietary component that enhances dietary diversity, supports antioxidant capacity, and contributes to overall health in athletes. Nevertheless, in order to clearly position microgreens as a performance-enhancing "ergogenic aid," further research is required, including long-term, randomized controlled trials across different sports disciplines that examine optimal dosage, timing of intake, and sport-specific effects. Future studies will help establish a stronger scientific foundation for the role of microgreens in athlete nutrition and contribute to the development of evidence-based, practical nutritional strategies.

Suggestions

Although the existing literature has extensively examined the nutritional composition of microgreens and their effects on general health, studies directly assessing their impact on sports performance and recovery remain limited. Most studies focus on indirect mechanisms or on the general effects of vegetable and antioxidant consumption. Future research should include long-term, randomized controlled trials encompassing different sports disciplines to determine the optimal intake amounts, timing, and sport-specific effects of microgreens. Furthermore, clarifying their bioavailability, influence on training adaptations, and effects on performance outcomes will help establish a stronger scientific foundation for the role of microgreens in athlete nutrition.

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