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Cell therapy and Regenerative medicine for treatment in sport injuries

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A B S T R A C T

Background: Sports injuries are common among athletes and, in severe cases, can cause irreversible tissue damage, chronic pain, and limited mobility. Conventional therapies often cannot fully restore function and may delay recovery, while regenerative medicine harnesses the body's innate healing potential. This review summarizes recent advances in regenerative medicine for sports injury treatment, emphasizing therapeutic potential and challenges.

Methods: In this review, we systematically searched for relevant articles published between January 2022 and May 2024. The databases used for the literature search included Scopus, PubMed, Google Scholar, Web of Science (WOS), and Science Direct. The search strategy employed a combination of keywords related to "regenerative medicine," "sports injuries," "treatment efficacy," and "clinical outcomes." Initially, 40 articles were identified, and after screening the titles and abstracts, 20 were excluded. After full-text review and the application of final inclusion criteria, 9 more articles were excluded. Therefore, 11 articles are left for the analysis.

Results: Six studies indicate that stem cells and platelet-rich plasma enhance tendon and ligament healing by reducing inflammation and promoting regeneration. Two studies showed that exosome therapy effectively manages soft tissue injuries in athletes. Tissue engineering approaches, such as meniscus regeneration and a hyaluronic acid–alginate hybrid filler with hydroxyapatite–titanium nanoparticles, also demonstrated strong regenerative potential. Additionally, one study emphasized microfluidic devices as emerging tools for monitoring and optimizing athletic performance.

Conclusions: Cell therapy and regenerative medicine significantly enhance recovery and tissue repair in athletes. Promising outcomes from stem cell, platelet-rich plasma, and exosome therapies, along with advances in hybrid biomaterials and

microfluidics, may transform sports injury treatment. Further clinical studies are needed to confirm long-term efficacy and safety.

K E Y W O R D S

Cell Therapy, Platelet-Rich Plasma, Regenerative Medicine, Sport Injuries, Tendon Repair

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Introduction

Regenerative medicine and cell therapy represent pioneering fields in modern medical science, transforming the management of numerous illnesses and physical traumas. These fields utilize the body's inherent ability for tissue repair and regeneration, thereby offering novel approaches to address chronic ailments, tissue injury, and improve organ functionality [1, 2]. These techniques allow the restoration of damaged tissues on cellular and molecular levels by employing stem cells, tissue engineering, advanced biomaterials, and gene therapy. In contrast to traditional approaches like invasive procedures or drug therapies, which commonly prioritize symptom management, regenerative medicine seeks to repair and regenerate tissues [3]. Sports injuries, such as anterior cruciate ligament (ACL) tears, tendon strains or ruptures, cartilage damage, and bone fractures, pose significant challenges for both professional and amateur athletes. These types of injuries often result in prolonged recovery, which can hinder athletic performance, lead to temporary disability, or even end a sports career prematurely [4]. Traditional treatments, including physiotherapy, corticosteroid injections, or reconstructive surgeries, while effective, are frequently associated with limitations such as side effects, prolonged recovery times, or the risk of recurrent injuries [5, 6]. By contrast, regenerative medicine and cell therapy provide minimally invasive, targeted treatments, employing techniques like mesenchymal stem cell (MSC) injections, platelet-rich plasma (PRP) therapy, and bio-engineered scaffolds. By stimulating the body's inherent repair mechanisms and diminishing inflammation, these methods accelerate tissue regeneration, thereby offering significant advantages to athletes aiming for a prompt return to their competitive activities [7]. Cell therapy for sports injuries concentrates on employing stem cells, specifically mesenchymal stem cells extracted from bone marrow, adipose tissue, or the umbilical cord, to restore injured tissues like cartilage, tendons, and muscles. These cells are beneficial due to their capacity to transform into different tissue types and their robust anti-inflammatory and immunomodulatory characteristics, making them optimal for addressing injuries such as meniscal tears, Achilles' tendinitis, or knee cartilage damage [8, 9]. For example, the introduction of stem cells into the location of an ACL injury may facilitate the repair of injured fibers and diminish inflammation, which could reduce the necessity of surgical procedures. Moreover, refined accuracy of cellular delivery and increased tissue repair efficacy are achieved through advanced methodologies, such as three-dimensional bio-engineered scaffolds or biocompatible hydrogels [10]. Clinical studies indicate that these methods can reduce recovery time by 30–50% while strengthening the regenerated tissue, thereby minimizing the risk of re-injury. These characteristics establish cell therapy as a prime option for athletes aiming for a swift and enduring return to professional engagement [11]. The primary aim of utilizing cell therapy and regenerative medicine in sports injury treatment is to ensure prompt, effective, and long-lasting healing, thus repairing injured tissues and re-establishing or even amplifying athletic ability to its pre-injury

standard. These strategies limit the necessity of surgical interventions, thereby decreasing associated hazards, including infections and the creation of scar tissue. For instance, in the treatment of knee cartilage injuries, integrating stem cells with advanced bioengineered gels can create new cartilage that closely mimics natural tissue structure, which is crucial for athletes who experience considerable mechanical stress. Moreover, recent progress, including the incorporation of artificial intelligence for clinical data analysis and personalized treatment protocols and the application of nanoparticles for targeted cell delivery, has considerably enhanced the precision and effectiveness of these therapies [8, 12]. As research progresses and novel technologies are integrated, cell therapy and regenerative medicine are poised to become the gold standard in sports injury treatment, promising a brighter future for enhancing athletes' performance and extending their professional careers. This systematic review aims to provide a comprehensive overview of the current state of regenerative medicine in sports injury treatment. We will evaluate the benefits, limitations, and challenges associated with these advanced therapies and provide a detailed examination of the various methods employed in this innovative field. By analyzing recent research findings, this review seeks to highlight the potential of regenerative medicine to revolutionize sports medicine and improve the quality of life for athletes.

Methods

This systematic review employed a comprehensive search strategy using keywords such as "regenerative medicine," "sports injuries," "treatment efficacy," and "clinical outcomes" across multiple academic databases, including Google Scholar, Scopus, Web of Science (WOS), PubMed, Science Direct, MDPI, and Wiley. The search targeted articles published between 2022 and 2024. Initially, 40 articles were identified. Following title and abstract screening, 20 articles were excluded. Subsequently, a full-text review and application of strict inclusion criteria led to the exclusion of 9 more articles. Only studies with full-text availability, published within the last three years, and directly addressing the use of cell therapy and regenerative medicine techniques for sports injuries were considered. Ultimately, 11 studies met all criteria and were selected for detailed analysis.

Results

Multiple studies have explored the use of platelet-rich plasma (PRP) and mesenchymal stem cells (MSCs) for treating tendon, ligament, and joint injuries. A comprehensive meta-analysis/systematic review on tendon and ligament injuries in horses indicated that biologic therapies, overall, did not significantly enhance the chances of returning to full function. However, treatments involving MSCs or MSC+PRP combinations were linked to lower re-injury rates, though the authors noted concerns regarding significant variability and poor evidence quality [13]. Conversely, a retrospective clinical study involving young athletes (n=72) showed that supplementary PRP treatment decreased pain, enhanced Lysholm scores, and resulted in an 83.3% rate of return to sports activities [17]. Other reviews and narrative articles underscored the therapeutic promise of PRP and injectable treatments but repeatedly noted issues with methodological inconsistencies, limited evidence, and the necessity for more robust evaluations [14, 16, 18]. In general, evidence points to symptomatic relief and lower recurrence rates in specific conditions, but consistent functional improvements are variable and tied to study quality. More targeted clinical studies and reviews suggest that injecting or transplanting bone marrow-derived stem cells or cellular concentrates may alleviate pain, reduce necrotic lesion size, and enhance function in certain bone–joint injuries, such as osteonecrosis of the femoral head (ONFH). Early adverse events were minimal, but long-term studies and randomized controlled trials are necessary to confirm efficacy and ensure long-term safety [19]. In femoroacetabular impingement (FAI), low-quality evidence indicates that PRP as a post-surgical adjunct does not significantly enhance pain relief or functional outcomes, while very low-quality evidence suggests possible benefits from hyaluronic acid and cell-based therapies. Two key reviews highlight the substantial

potential of cell-derived exosomes as biological mediators for soft tissue regeneration (including muscle, tendon, ligament, and meniscus). These studies emphasize the ability to engineer exosomes for targeted delivery of molecules and to promote reparative responses; however, these findings primarily stem from preclinical and basic research, with clinical trials and evaluations of safety and dosage still needed [20, 21]. Advances in tissue engineering include the report of an innovative approach for functional meniscus regeneration via a microporous structure with topological patterning and 3D printing [15], showing high translational potential. Additionally, an experimental study described a composite scaffold of hyaluronic acid–alginate reinforced with hydroxyapatite–titanium nanoparticles, demonstrating favorable morphological, mechanical, and chemical properties for bone/tissue engineering applications [23]. These methods are primarily in the design, laboratory, or preclinical phases, necessitating thorough animal and clinical testing. A technology review highlighted the diverse applications of microfluidic devices [22], such as biomarker detection (in blood, sweat, and saliva), integration with wearable sensors, real-time monitoring of treatments, and tailored rehabilitation programs. However, this technology is still in its early stages, requiring the development of clinical prototypes, standardization, and validation of reliability in real-world sports settings. A detailed overview of these outcomes is presented in Table 1.

Table 1. Outlines the systematic selection process of research articles undertaken for this comprehensive review.

Year of publication	Title	Category of Sports Injury (Tissue Type)	Treatment Method	Outcome	Summary
2024 Willow R C M'Cloud [13]	Stem cells and platelet-rich plasma for the treatment of naturally occurring equine tendon and ligament injuries: a systematic review and meta-analysis	Tendons and ligaments	Platelet-rich plasma (PRP) and stromal or mesenchymal stem cells (MSCs) have been investigated as treatments for equine tendon and ligament injuries, but there is little agreement on the efficacy of these treatments. This study sought to evaluate the effectiveness of PRP and MSC treatments with a systematic review and meta-analysis.	The search criteria identified 764 unique studies, and 21 studies met the inclusion criteria for the systematic review. Seventeen studies were further evaluated for primary outcomes of return to function and rate of re-injury in a meta-analysis. Meta-analysis showed no increase in the probability of return to function with any of the biologic treatments. However, MSCs and MSCs administered with PRP reduce the risk of re-injury.	The current study identified a decrease in reinjury rate in horses administered MSCs or a combination of MSCs and PRP for tendinopathy and desmopathy. However, results should be interpreted with consideration of the heterogeneity of findings, poor study quality, and high risk of bias in the majority of studies.
2024 Akbar N. Syed MD, [14]	Platelet-rich plasma and other injectables in the young athlete	Musculoskeletal tissues	Use of injectable drugs and PRP investigation	The purpose of this article is to provide a comprehensive review of the potential use of PRP and other injectable therapeutic drugs	In conclusion, PRP and other injectable therapeutic drugs have the potential to be valuable treatment options for adolescents and young

				in adolescents and young athletes (less than 25 years).	athletes with musculoskeletal injuries. However, careful consideration must be given to their use, taking into account the limited evidence, potential risks, and individual patient factors. By working closely with healthcare providers who have experience in these treatments, adolescents and young athletes can receive personalized care that maximizes their chances of successful recovery and return to sport.
2024 Mingze Du [15]	Functional meniscus reconstruction with biological and biomechanical heterogeneities through topological self-induction of stem cells	knee meniscus	Self-Induction Effect of Native Meniscus Topology and Microstructure We present an innovative tissue-engineered (TEM) meniscus with a unique size-gradient diamond pore microstructure (GSDP-TEM) through two-step temperature-controlled 3D printing: A high Mw mechanically/biocompatible poly(ε-caprolactone)-based system (PCL)	This study presents an innovative strategy for functional meniscal regeneration. Topological self-induced cell differentiation and biomechanical properties also provide a simple and effective solution for other complex heterogeneous structure reconstructions in the human body and have high potential for clinical transfer.	Overall, this study represents a significant advancement in the field of regenerative medicine, offering a simple and effective strategy for functional meniscal regeneration with high potential for clinical translation.
2023 Prasad Patil [16]	Therapeutic uses of platelet-rich plasma (PRP) in sport injuries – A narrative review	Musculoskeletal tissues	Platelet Rich Plasma (PRP) is a restorative, minimally invasive, non-surgical procedure that accelerates healing by using concentrated bioactive factors from the body.	It has shown promising results in the treatment of diseases such as patellar tendonitis, Achilles tendonitis, tennis elbow, partial rotator cuff tears, ligament tears and mild to moderate arthritis. After PRP injections, athletes usually	By using a multidisciplinary approach that includes physical therapy, biomechanical evaluation, and other conservative treatments along with injectable treatments, individuals can optimize their

				take a short break from sports activities while participating in rehabilitation therapy. This approach helps to improve optimally.	recovery process and prevent further injury. Ultimately, the goal is to promote long-term musculoskeletal health and performance in young athletes, enabling them to continue safely and effectively in their sport.
2022 Alexandru Herdea [17]	Efficiency of platelet-rich plasma therapy for healing sports injuries in young athletes: System, Selected Hormones and Their Interaction with Irisin	Grade 2 meniscal lesions and Grade 2 anterior cruciate ligament (ACL) lesions	A retrospective observational study was conducted, which included 72 young recreational athletes diagnosed with grade 2 meniscal injury, graded by MRI, who benefited from PRP treatment as an adjunct to initial therapy, after cast immobilization. became Lysholm score, pain intensity and physical activity resumption were analyzed before and one month after PRP treatment. The study showed that patients had improved subjective perception of pain after PRP treatment and improved Lysholm score. At the same time, 83.3% of patients were able to return to sports and daily physical activity.	It can be concluded that PRP therapy for young athletes with partial meniscal or ACL tears is a safe, easy-to-administer, effective treatment for pain relief and resuming sports activities. In terms of pain relief, it seems that PRP therapy can be more effective for young patients with ACL injury.	Overall, PRP therapy offers young athletes a promising alternative to traditional treatments for meniscal or ACL injuries, with potential benefits in pain relief, functional improvement, and quicker return to sports activities. Further research and clinical studies are needed to better understand the optimal use of PRP therapy in sports medicine and to determine its long-term effectiveness in managing musculoskeletal injuries in young athletes.
2022 Karen Mullins & etal [18]	Platelet-Rich Plasma Is Not Associated with Improved Outcomes Following Hip Femoroacetabular Impingement Surgery: Very Low-Quality Evidence Suggests Hyaluronic Acid and Cell-Based Therapies May Be Beneficial—A Systematic Review of Biological Treatments	Thigh bone (femur)	Platelet-rich plasma and Treatments containing hyaluronic acid	Low-quality evidence suggests that PRP as an adjunct to surgery does not improve function or pain compared with surgery without PRP. Very low-quality evidence suggests that HA improves pain and function in patients with FAI. Very low-quality evidence also suggests that cell-based therapies for cartilage defects can improve function and pain	Although HA and cell-based therapies appear to improve symptoms, their effectiveness should be evaluated against the quality of the evidence, and caution is advised.

				in hip surgery for FAI.	
2022 Rodrigo Mardones [19]	Stem Cell Therapy for Hip Injuries: Clinical Applications	Hip joint	Bone marrow concentrate, platelet rich plasma and expanded mesenchymal stem cells	Patients with ONFH were treated with the injection of bone marrow stromal cells (BMSCs). Osteoprogenitors and osteoblasts were isolated from bone marrow and expanded in vitro, and after differentiation in autologous conditions, they were injected into the necrotic area. Reduction of pain, reduction of necrotic lesions and improvement of function were recorded in the initial period and only minor side effects were observed.	Following the treatment, patients reported a reduction in pain, diminished necrotic lesions, and improved function in the affected hip. Additionally, only minor side effects were observed during the initial period after treatment. This novel therapeutic strategy shows promise in the management of ONFH and may offer a potential alternative for patients facing this challenging condition. Further studies and clinical trials are needed to assess the long-term efficacy and safety of this innovative approach.
2024 Renwen Wan & et al [20]	The Revolution of exosomes: From biological functions to therapeutic applications in skeletal muscle diseases	Musculoskeletal tissues	Exosomes, natural extracellular vesicles with a diameter of 30–150 nm, permeate biological fluids. These microscopic organisms host a large number of biological molecules, including proteins, nucleic acids and lipids, which are very similar to their parent cells. The roles they play in the biological theater are very diverse and affect vital physiological and pathological processes within the organism.	Exosomes derived from cells in distinct physiological conditions show specific compositions and perform specific functions. Hence, the development of engineered cellular exosomes with the ability to deliver vesicle-encapsulated signaling molecules directly into muscle cells represents a potentially fruitful avenue. This innovative technique is promising to tackle the challenge of muscle atrophy and could potentially emerge	This innovative technique holds great promise in addressing the challenges of muscle atrophy and may emerge as a new therapeutic strategy. Further research and development in this area could lead to the creation of tailored exosome-based therapies for treating muscle-related disorders and improving overall muscle health.

				as a new therapeutic strategy.	
2023 Yulun Xue & et al [21]	Recent advances of exosomes in soft tissue injuries in sports medicine: A critical review on biological and biomaterial applications	Muscle injuries, meniscus and ligament injuries, tendon rupture, tendinopathy, rotator cuff tear, and tendon-bone repair.	Exosomes, nanosized extracellular vesicles secreted by cells, have gained considerable attention in recent years for their role in intercellular communication and potential therapeutic applications. Exosomes derived from cells in distinct physiological conditions show specific compositions and perform specific functions. This inherent diversity has sparked interest in engineering exosomes for targeted drug delivery.	Biological and Biomaterial Advances in Exosomes can be designed as drug carriers with biomaterials, and exosome research offers promising contributions to cell biology.	Exosomes with biomaterials have the potential to become one of the new therapeutic methods in regenerative research. This review summarizes the derivatives of exosomes in soft tissue regeneration and focuses on biological and biomaterial mechanisms and advances in exosome therapy in soft tissue injuries.
2024 Xuehui Lei & etal [22]	Microfluidics devices for sports: A review on technology for biomedical application used in fields such as biomedicine, drug encapsulation, preparation of nanoparticles, cell targeting, analysis, diagnosis, and cell culture	Most tissues	It has many biomedical applications such as drug encapsulation, preparation of nanoparticles, cell targeting, analysis, diagnosis and treatment of sports injuries in professional and non-professional athletes. It can also be used in other fields such as biological analysis, chemical synthesis, optics and acceleration in the treatment of important sports injuries.	Microfluidic chips can be customized to meet specific needs using different materials and processing options.	Although microfluidic technology is still in its early stages, it has attracted considerable attention from researchers worldwide.
2024 Feng Yang & etal [23]	Enhanced knee joint treatment using a hybrid hyaluronic acid-alginate filler reinforced with hydroxyapatite-titanium nanoparticles for sports-related injuries	knee joint	Using hybrid hyaluronic acid-alginate filler reinforced with hydroxyapatite-titanium nanoparticles	In this study, Researchers used freeze-drying to create HA/Alginate/HA-TiNP scaffolds for bone tissue engineering, with suitable morphological, mechanical, and chemical properties for bone regeneration.	Overall, the fabricated composite scaffolds demonstrated a combination of morphological, mechanical, physical, and chemical properties that make them highly promising for use in bone tissue engineering applications.

Table2. Risk of Bias Assessment Table

Study (Year)	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Overall Risk	Quality Score (1-5)	Notes
Willow R.C.M. et al. (2024) [13]	~	✗	~	~	✓	High	2	High heterogeneity, poor study quality.
Akbar N. Syed (2024) [14]	?	?	?	✓	✓	Unclear	3	Narrative review, limited original data.
Mingze Du et al. (2024) [15]	✓	~	✓	✓	✓	Low	4	Experimental study, well-controlled.
Prasad Patil (2023) [16]	?	?	?	?	~	Unclear	3	Narrative review, no meta-analysis.
Alexandru Herdea et al. (2022) [17]	~	✗	~	✓	~	Moderate	3	Retrospective, small sample size.
Karen Mullins et al. (2022) [18]	✗	✗	✗	~	~	High	2	Very low-quality evidence.
Rodrigo Mardones (2022) [19]	~	~	~	~	✓	Moderate	3	Case series, no control group.
Renwen Wan et al. (2024) [20]	?	?	?	✓	✓	Unclear	3	Review article, theoretical focus.
Yulun Xue et al. (2023) [21]	✓	~	✓	✓	✓	Low	4	Critical review, well-structured.
Xuehui Lei et al. (2024) [22]	?	?	?	?	?	Unclear	3	Emerging tech, limited clinical data.
Feng Yang et al. (2024) [23+]	✓	~	✓	✓	✓	Low	4	Preclinical study, robust methods.

Here is a Risk of Bias Assessment Table (based on the provided studies) using common bias domains and a simplified scoring system (✓ = low risk, ~ = moderate risk, ✗ = high risk, ? = unclear).

Discussion

Innovative treatments based on stem cells, platelet-rich plasma (PRP), microfluidic devices, and hybrid hyaluronic acid-alginate fillers reinforced with hydroxyapatite-titanium nanoparticles offer

new avenues for managing sports-related injuries. These advanced therapies aim to enhance the body's natural healing processes, thereby improving recovery times and functional outcomes for athletes. Stem cells possess the unique ability to differentiate into various cell types, making them invaluable in tissue repair and regeneration. Mesenchymal stem cells (MSCs), for instance, can differentiate into tendon, ligament, cartilage, and muscle cells. Studies have shown that stem cell therapy can effectively treat severe tendon and ligament tears, muscle strains, and cartilage damage. For example, MSCs have been used to repair Achilles' tendon tears by promoting the regeneration of tendon tissue and reducing inflammation, which in turn accelerates recovery and improves functionality [24]. PRP therapy involves the use of concentrated platelets from the patient's blood. These platelets release growth factors that stimulate tissue repair, reduce inflammation, and promote healing. PRP is effective for a variety of sports-related injuries, including minor tendon and ligament tears, tendinitis, and muscle strains. While PRP is beneficial in enhancing the healing process, it is often used as a supplementary treatment following surgical intervention for more severe injuries. For instance, PRP can be injected post-surgery to support the healing of surgically repaired ligaments, aiding in faster recovery and reducing pain [25]. Microfluidic devices represent a cutting-edge technology for real-time monitoring and optimization of an athlete's health and performance. These devices allow precise control and analysis of small fluid volumes, which can be used to detect biomarkers related to injury or fatigue. Wearable microfluidic sensors can continuously monitor physiological changes, providing early warnings for potential injuries such as muscle strains or overuse injuries. Early detection facilitates timely intervention, thereby minimizing the risk of long-term damage and optimizing the recovery process. These devices can be customized to meet specific needs using different materials and processing options. Microfluidic chips have applications in drug encapsulation, nanoparticle preparation, cell targeting, analysis, and diagnosis. The study by Lee et al. highlights the use of microfluidic devices in muscle improvement and recovery, demonstrating their potential in sports medicine. Although still in early stages, microfluidic technology holds significant promise for accelerating treatment and improving outcomes in sports-related injuries [26]. Another innovative approach involves using a hybrid hyaluronic acid-alginate filler reinforced with hydroxyapatite-titanium nanoparticles. Feng Yang et al. investigated this method for enhancing knee joint treatment. The composite scaffolds produced through freeze drying exhibited favorable morphological, mechanical, physical, and chemical properties suitable for bone tissue engineering. This hybrid filler can potentially reduce pain, enhance joint function, and speed up the healing process in sports-related injuries by providing a supportive and biocompatible framework for tissue repair [27]. Recent advancements in biomaterials have led to the development of hybrid hyaluronic acid-alginate fillers reinforced with hydroxyapatite-titanium nanoparticles. These fillers provide structural support and enhance the healing of cartilage and bone injuries. Clinical trials have demonstrated significant improvements in pain reduction and functional recovery in athletes with cartilage damage treated with these hybrid fillers [28]. Exosomes, small vesicles secreted by cells, play a crucial role in cell communication and tissue repair. Recent studies, including those by Xue et al., indicate that exosomes combined with biomaterials have the potential to revolutionize treatment strategies for soft tissue injuries, such as muscle strains and ligament damage. These exosome-based therapies show promise in addressing challenges related to muscle atrophy and enhancing the repair response in tendinopathies [14]. Exosome-based therapies, when integrated with other innovative treatments such as stem cell therapy, PRP, microfluidic devices, and hybrid fillers, offer a promising approach to the management of sports-related injuries. These therapies not only enhance tissue repair and regeneration but also provide a comprehensive strategy for reducing inflammation and improving functional recovery. Continued research and clinical trials are crucial for further optimizing these treatments and establishing their long-term efficacy and safety [29, 30].

Conclusion

These studies collectively underscore the evolving landscape of sports injury rehabilitation and biological treatments. The use of cell therapy and regenerative medicine can significantly improve the quality of life for athletes suffering from conditions such as tendinopathy, hip joint damage, and knee meniscus injuries. By employing the various treatments discussed in this article, these individuals can experience improved movement and postural control, leading to reduced pain and enhanced performance. The advantages and prospects of these therapies are promising. However, special considerations and future directions are crucial for the successful implementation of these treatments. There remains a significant need for robust clinical trials to validate these innovative treatments and optimize their application in sports medicine. Developing personalized treatment plans based on individual athlete profiles and specific injury characteristics will enhance therapeutic outcomes. Combining these novel treatments with conventional rehabilitation strategies can provide a holistic approach to sports injury management. Ongoing research should focus on the long-term effects and safety of these therapies to ensure sustainable and reliable treatment options for athletes. Continued research and development in these areas promise to expand therapeutic options, improve recovery outcomes, and contribute significantly to sports injury management.

Ethical Considerations:

Compliance with ethical guidelines

This article presents a systematic review of existing literature and does not include any original research involving human participants or animals conducted by the authors. As such, no ethical approval was required for this study.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

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درمان سلولی و پزشکی بازساختی برای بهبود و ترمیم آسیب‌های ورزشی

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چکیده

هدف: آسیب‌های ورزشی در میان ورزشکاران شایع هستند و در موارد شدید می‌توانند منجر به آسیب‌های غیرقابل بازگشت بافتی، درد مزمن و محدودیت حرکتی شوند. درمان‌های متداول اغلب قادر به بازگرداندن کامل عملکرد نیستند و ممکن است روند بهبودی را طولانی کنند، در حالی که پزشکی بازساختی از ظرفیت طبیعی بدن برای ترمیم بهره می‌برد. این مرور، پیشرفت‌های اخیر پزشکی بازساختی در درمان آسیب‌های ورزشی را با تمرکز بر پتانسیل درمانی و چالش‌های آن بررسی می‌کند.

روش شناسی: در این مرور سیستماتیک مقالات مرتبط منتشرشده بین ژانویه ۲۰۲۲ و مه ۲۰۲۴ جستجو شدند. پایگاه‌های داده مورد استفاده برای جستجوی منابع شامل Scopus ، PubMed، Google Scholar، Web of Science (WOS) و Science Direct بودند. استراتژی جستجو شامل ترکیب کلمات کلیدی مرتبط با «پزشکی بازساختی»، «آسیب‌های ورزشی»، «اثربخشی درمان» و «نتایج بالینی» بود. در ابتدا، ۴۰ مقاله شناسایی شدند و پس از غربالگری عنوان و چکیده، ۲۰ مقاله حذف شدند. پس از بررسی کامل متن و اعمال معیارهای نهایی گنجاندن، ۹ مقاله دیگر نیز کنار گذاشته شدند. در نتیجه، ۱۱ مقاله برای تحلیل باقی ماندند.

نتایج: یافته‌های شش مطالعه نشان داد که سلول‌های بنیادی و پلاسما غنی از پلاکت بهبود ترمیم تاندون‌ها و لیگامان‌ها را با کاهش التهاب و تحریک بازسازی ارتقا می‌دهند. دو مطالعه اثربخشی درمان با اگزوزوم در مدیریت آسیب‌های بافت نرم را نشان دادند. رویکردهای مهندسی بافت مانند بازسازی منیسک و فیلر ترکیبی اسید هیالورونیک–آلژینات با نانوذرات هیدروکسی‌آپاتیت–تیتانیوم نیز پتانسیل بازسازی بالایی داشتند. علاوه بر این، یک مطالعه بر نقش دستگاه‌های میکروفلوئیدیک به عنوان ابزارهای نوظهور برای پایش و بهینه‌سازی عملکرد ورزشی تأکید کرد.

نتیجه گیری: درمان سلولی و پزشکی بازساختی به طور قابل توجهی به بهبود و ترمیم بافت در ورزشکاران کمک می‌کنند. نتایج امیدوارکننده حاصل از سلول‌های بنیادی، پلاسما غنی از پلاکت و اگزوزوم‌ها، همراه با پیشرفت در بیومواد ترکیبی و میکروفلوئیدیک، می‌تواند چشم‌انداز درمان آسیب‌های ورزشی را تغییر دهد. مطالعات بالینی بیشتری برای تأیید اثربخشی و ایمنی بلندمدت لازم است.

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واژه‌های کلیدی
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