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Estrategias de Recuperación para Atletas con Discapacidad

Recovery Strategies for Athletes with Disabilities

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Resumen

La recuperación es un factor determinante tanto para el rendimiento como para la salud en los deportes adaptados, debido a la interacción entre las demandas funcionales, fisiológicas y psicológicas asociadas a los diversos tipos de discapacidades. Esta revisión narrativa integró la evidencia científica sobre métodos de recuperación utilizados en atletas con discapacidad, considerando aspectos como la fatiga, el daño muscular, el sueño, la nutrición, la hidratación, la suplementación, la carga de entrenamiento y la regulación psicológica. La literatura analizada revela datos heterogéneos, con limitaciones evidentes en la caracterización de las poblaciones deportivas, así como desafíos asociados a las restricciones biomecánicas, al dolor crónico y a las demandas emocionales que presentan los atletas. Asimismo, se destaca la necesidad de realizar intervenciones individualizadas y multidisciplinarias respaldadas por evidencia científica para optimizar la recuperación de los atletas de deportes adaptados. Finalmente, se plantea desarrollar y evaluar nuevas líneas de investigación que propongan estrategias que faciliten el rendimiento, la seguridad y el bienestar general de los atletas con discapacidades.

Palabras Clave: discapacidad, deporte adaptado, recuperación, fatiga, atleta.

Abstract

Recovery is a determining factor for both performance and health in adapted sports, due to the interaction between the functional, physiological, and psychological demands associated with various types of disabilities. This narrative review integrated scientific evidence on recovery methods used in athletes with disabilities, considering aspects such as fatigue, muscle damage, sleep, nutrition, hydration, supplementation, training load, and psychological regulation. The analyzed literature reveals heterogeneous data, with evident limitations in the characterization of athletic populations, as well as challenges associated with biomechanical restrictions, chronic pain, and the emotional demands placed on athletes. The need for individualized and multidisciplinary interventions supported by scientific evidence to optimize recovery in athletes with disabilities is also highlighted. Finally, the review proposes developing and evaluating new lines of research that suggest strategies to facilitate the performance, safety, and overall well-being of athletes with disabilities.

Key words: disability, adapted sport, recovery, fatigue, athlete.

Introduction

The current role of recovery in sport is critical during training and competition (Peake, 2019). In many sports, where intense training sessions and frequent matches are common, recovery strategies are essential for maintaining performance and preventing injuries, as well as for managing fatigue and damage (Kellmann et al., 2019). Planned recovery processes allow athletes to restore energy levels, repair damaged tissues, and recover mentally and physically between games or training sessions (Nowakowska et al., 2019). This provides an opportunity for the body to adapt, optimize performance, and reduce the risk of overuse injuries or exhaustion. These processes become even more relevant under demanding conditions, such as congested tournaments (Martínez-Guardado et al., 2020).

In team sports, recovery also plays a vital role in enhancing teamwork and cohesion. When athletes are well-rested and in peak physical condition, they can execute complex game plans, make accurate decisions, and communicate effectively with their teammates (Almonroeder et al., 2020; Trecroci et al., 2020). Furthermore, optimal recovery helps manage fatigue, enabling athletes to maintain high intensity during matches and training sessions, which is crucial for team success. Despite this, athletes in these types of sports often lack foundational knowledge of strategies or perceive them as ineffective (Crowther et al., 2017).

In professional or competitive team sports, the margins of victory are often very narrow, and the ability to recover quickly and efficiently translates into a competitive advantage. Teams that prioritize recovery as an integral part of their training and competition regimen can gain an edge over their opponents (Calleja-González et al., 2018). By implementing recovery strategies such as nutrition, hydration, sleep optimization, active recovery techniques, and proper workload management, elite teams can maximize their performance potential and maintain a sustained level of success throughout the season (Reilly & Ekblom, 2005).

Proper recovery management is crucial for maximizing performance and promoting the well-being of athletes with disabilities (Szabo & Kennedy, 2022). These athletes often face unique challenges due to their physical or cognitive limitations, which can influence their ability to recover and maintain optimal energy levels during training and competition (Wilson & Clayton, 2010). Therefore, understanding and applying effective recovery management methods and strategies becomes essential for athletic success and overall health (Szabo & Kennedy, 2022).

This section examines a range of approaches designed specifically for athletes with disabilities to support effective recovery. Both the physical and psychological aspects of recovery are addressed, acknowledging the issue's complexity and the need for a holistic approach.

Additionally, the way this data can inform adaptations to training and workload planning is discussed. Lifestyle factors, such as sleep and nutrition, which play a crucial role in recovery management is considered. Furthermore, practical strategies for managing and preventing recovery issues in athletes with disabilities will be explored. Finally, active and passive recovery techniques will be discussed, along with the importance of adapting and modifying exercise to meet individual needs.

However, it is recognized that each athlete with a disability is unique, and the principle of individuality must prevail, so what works for one athlete, particularly with athletes with disabilities, is likely not suitable or optimal for another. Therefore, the importance of individualization in recovery management will also be addressed, underscoring the need for an athlete-centered approach that accounts for their abilities, goals, and preferences.

Throughout this section, scientific evidence will be presented demonstrating the effectiveness of recovery methods and strategies in adapted sports, with particular focus on football. This evidence will serve as a tool and guide for other athletes, coaches, and professionals involved in their training and optimization. Therefore, this part aims to provide an understanding of recovery methods and strategies useful for athletes with disabilities. In doing so, this review aims to foster an environment that promotes optimal performance and well-being for these athletes.

Methods

Study Design

This narrative review was conducted to synthesize current knowledge on recovery strategies for athletes with disabilities. The approach focused on identifying, integrating, and conceptually organizing findings from diverse research fields rather than adhering to systematic review protocols. This design was selected because of the wide variability in disabilities, sports modalities, and recovery needs, thereby enabling a flexible and practical interpretation of the available evidence.

Literature Search

A comprehensive search of scientific literature was conducted in PubMed/MEDLINE, Scopus, Web of Science, SPORTDiscus, and Google Scholar, including publications through December 2025. A combination of keywords and Boolean operators related to adapted sport and recovery methods was used, such as "athletes with disabilities", "Paralympic athletes", "adaptive sports", "recovery", "fatigue management", "psychological recovery", "hydration", "sleep", "pain", "muscle damage", and "rehabilitation". Additional relevant sources were identified through manual searches in the reference lists of the selected articles and reviews.

Eligibility Criteria

Studies were included if they addressed recovery-related aspects in athletes with disabilities from physiological, psychological, or functional perspectives. Publications were considered regardless of design, encompassing empirical studies, reviews, theoretical models, case reports, theses, and position statements. Research involving athletes from any impairment classification, physical, sensory, or intellectual, and from varied competitive levels was included. English-language, Spanish-language, and Portuguese-language literature was accepted to ensure broader representation of global adaptive sport research.

Data Extraction and Synthesis

Data was extracted on key domains associated with recovery, including sleep and rest practices, nutritional and hydration strategies, neuromuscular and metabolic demands, psychological recovery, pain and stress management, and technological or multidisciplinary support. The synthesis followed a thematic organization, highlighting both universal recovery principles and adaptations required for specific disabilities, sports environments, and workloads. Emphasis was placed on practical implications and evidence-informed recommendations.

Limitations

As a narrative review, this work does not provide a systematic assessment of study quality or a quantitative integration of results. The heterogeneity of methodologies and the limited availability of data in some athlete subgroups restrict the generalizability of conclusions. However, the narrative format allows for a more comprehensive and contextual interpretation of emerging knowledge and its translation into practical recovery management for athletes with disabilities.

Fundamentals of recovery in athletes with disabilities

Recovery is a vital component of any athlete's training regimen; these considerations are particularly relevant in athletes with disabilities (Szabo & Kennedy, 2022). In fact, for these athletes, recovery becomes even more crucial due to the unique challenges they face (Wilson & Clayton, 2010). Participating in team sports and adapted physical activities can place additional stress on the body, both physically and mentally (Sikorska & Gerc, 2022). Recovery allows the body to repair and rebuild tissues, replenish energy stores, and restore overall well-being. It plays a critical role in improving performance, preventing injuries, and promoting the long-term health of athletes with disabilities (Nowakowska et al., 2019).

The effort and demands of training and competition can lead to increased recovery demands, which can be amplified in individuals with disabilities (Almonroeder et al., 2020; Trecroci et al., 2020). Appropriate recovery strategies, such as rest and sleep, allow the body to replenish energy stores and reduce recovery time, enabling athletes to perform at their best (Fischer et al., 2020). Furthermore, recovery helps prevent overtraining, which is particularly important for athletes with disabilities who may need to balance their training load to avoid exacerbating their disabilities carefully (Myrick, 2015).

In addition to physical recovery, athletes with disabilities also benefit from the psychological aspects of the recovery process. Participating in disability sports often requires additional mental resilience and coping strategies. Recovery periods provide valuable opportunities for relaxation and stress reduction, allowing athletes to unwind, refocus, and maintain a positive mindset (Sikorska & Gerc, 2022). By addressing both the physical and psychological aspects of recovery, athletes with disabilities can improve their overall well-being, enhance their performance, and sustain their passion for sport.

In conclusion, understanding the importance of recovery for athletes with disabilities is vital to their success and well-being. It allows them to manage their recovery, prevent injuries, and maintain optimal performance levels (Kellmann et al., 2019). By incorporating appropriate recovery strategies into their training routines, athletes with disabilities can maximize their potential, improve their overall health, and continue pursuing their athletic goals with passion and resilience.

The recovery of athletes with disabilities presents unique challenges and requires specific considerations due to the individualized nature of disabilities. One of the main challenges is the wide range of disabilities and their diverse impacts on the body. Each disability can affect different physiological systems, motor skills, and sensory functions, making it essential to tailor recovery approaches to meet each athlete's specific needs. Furthermore, the psychological and emotional aspects of recovery cannot be overlooked in athletes with disabilities. Coping with the limitations and challenges associated with disabilities can place significant mental and emotional strain on athletes. Therefore, recovery programs should incorporate strategies to address the unique psychological needs of athletes with disabilities, such as stress management techniques, access to mental health support, and fostering a supportive and inclusive environment (Fiorilli et al., 2021). Another consideration is the importance of a multidisciplinary approach to rehabilitation. Athletes with disabilities may need to work with healthcare professionals, such as physical therapists, occupational therapists, and sports psychologists, to develop a comprehensive rehabilitation plan. These professionals can provide specialized guidance, adaptive techniques, and support to assist in the recovery process. Furthermore, the involvement of coaches, trainers, and caregivers who understand the specific needs and challenges of athletes with disabilities is critical to developing effective rehabilitation strategies.

In conclusion, the rehabilitation of athletes with disabilities requires special attention to the specific challenges they face. Tailoring rehabilitation approaches to individual disabilities, addressing psychological factors, and implementing a multidisciplinary approach are key considerations for supporting athletes with disabilities in their rehabilitation. By recognizing and addressing these issues, athletes can optimize their recovery, improve their performance, and promote their overall health.

Physiology of recovery in athletes with disabilities

Recovery is a dynamic physiological process during which the energetic system recovers, damaged muscle tissue is healed, and the body adjusts to meet the required performance during training or competition. For athletes with disabilities, the recovery process can differ from that of those without disabilities, with a large proportion of this discrepancy being related to the specificity of these individuals (Szabo & Kennedy, 2022). However, the fundamental principles of recovery remain the same. These include rest, nutrition, hydration, and appropriate strategies for managing fatigue and promoting tissue repair.

Disabilities can influence significantly the recovery mechanisms of the body. Some physiological processes may be altered or require modifications, depending on the particular nature and extent of the disability. Knowledge regarding how disabilities affect those processes is needed for targeted recovery modalities that address specific challenges. Understanding how disabilities influence these physiological processes is essential for developing targeted recovery strategies that address specific challenges (Sellami et al., 2023; Szabo & Kennedy, 2022).

Several factors influence the recovery process in athletes with disabilities, and considering these factors is crucial for designing effective recovery protocols (Szabo & Kennedy, 2022).

The type and severity of the disability can significantly affect the recovery process. Some disabilities may involve chronic pain, joint instability, or compromised range of motion, requiring careful management during the recovery phase. Understanding the specific challenges posed by each type of disability is essential for tailoring recovery interventions accordingly (Szabo & Kennedy, 2022).

Training load and intensity directly influence the recovery demands placed on the body. Athletes with disabilities often participate in adapted training programs designed to meet their needs. However, it is crucial to strike a balance between challenging workouts and adequate recovery time. Training load and intensity must be carefully controlled to avoid overtraining, optimize adaptation, and minimize the risk of injury (Day & Wadey, 2016).

Age and overall health are important factors that influence the recovery of athletes with disabilities. Older athletes may experience slower recovery rates and greater susceptibility to injury. Additionally, athletes with pre-existing health conditions or comorbidities require specialized care to ensure optimal recovery (Day & Wadey, 2016). Consider customizing recovery plans based on age and general health factors to meet the individual needs of each athlete with a disability.

Understanding the physiology of recovery in athletes with disabilities involves recognizing the unique challenges posed by disabilities and adapting recovery strategies accordingly (Szabo & Kennedy, 2022). By considering the type and severity of the disability, training load and intensity, age, and overall health, coaches, trainers, and healthcare professionals can develop effective recovery protocols that promote optimal recovery, enhance performance, and support the overall well-being of athletes with disabilities.

Components of recovery in athletes with disabilities

Recovery is a multifaceted process that encompasses several components essential to the well-being and performance of athletes with disabilities (Calleja-González et al., 2021; see Figure 1). Understanding these components is crucial for designing comprehensive recovery plans tailored to the unique needs of people with disabilities (Reilly & Ekblom, 2005).

A key component of recovery is rest and sleep. Adequate rest allows the body to replenish energy reserves, repair damaged tissues, and promote overall recovery. Sleep quality is particularly important because it supports both physical and cognitive restoration. Athletes with disabilities should prioritize creating a conducive sleep environment and adopting good sleep hygiene practices to optimize their recovery (Roberts et al., 2021).

Figure 1

Recovery framework: domains and elements

Nutrition and hydration are also crucial components of recovery (Graham-Paulson et al., 2015). Adequate nutrition provides the necessary nutrients for tissue repair, muscle regeneration, and energy replenishment. Athletes with disabilities must focus on a well-balanced diet that meets their individual nutritional needs, which are often not reported as adequate (Hertig-Godeschalk et al., 2023). Furthermore, adequate hydration is vital for optimal performance and recovery. Hydration strategies should be tailored to accommodate any physical limitations or special considerations associated with disability.

Active recovery techniques form another important component of the recovery process. These techniques, such as stretching, mobility exercises, and low-intensity workouts, help promote blood circulation, reduce muscle soreness, and improve flexibility. Athletes with disabilities may require adapted or modified exercises to accommodate their specific disabilities while still benefiting from active recovery (Kennedy et al., 2018; Oliver & Driller, 2021).

Psychological recovery is an often-overlooked but critical component for athletes with disabilities. Coping with disabilities and the challenges they bring can affect an athlete's mental well-being. Incorporating stress-management strategies, relaxation techniques, and psychological support can help athletes maintain a positive mindset, reduce anxiety, and improve overall recovery (Macdougall et al., 2015).

By addressing the various components of recovery, including rest and sleep, nutrition and hydration, active recovery techniques, and psychological well-being, athletes with disabilities can optimize their recovery process. Tailoring these components to the individual's specific disability and needs is essential to promoting physical and mental rejuvenation, improving performance, and supporting long-term athletic success (Szabo & Kennedy, 2022).

Rest and sleep

Rest and sleep play a crucial role in the recovery process of athletes with disabilities, just as they do in athletes without disabilities. Adequate rest and quality sleep are essential to allow the body to repair and regenerate, optimizing physical and cognitive recovery (Roberts et al., 2021).

For athletes with disabilities, who may experience additional physical and mental stress, ensuring adequate rest is even more important. Participating in sports and physical activities with disabilities can place greater demands on the body, leading to muscle fatigue, joint stress, and mental exhaustion. By incorporating rest periods into their training programs, athletes with disabilities allow their bodies to recover and restore their basic functions (Grade et al., 2023).

Sleep quality is equally vital for recovery. During sleep, the body undergoes several physiological processes that promote tissue repair, hormonal regulation, and mental restoration (Hosker et al., 2019). Athletes with disabilities should prioritize creating a conducive sleep environment by ensuring comfort and minimizing disruptions (Durán Agüero et al., 2015). Implementing consistent sleep routines and practicing good sleep hygiene, such as avoiding screens before bed and maintaining a regular sleep schedule, can help optimize sleep quality and duration (Fox et al., 2020).

In addition to physical recovery, sleep contributes to cognitive function and emotional well-being. It plays a role in memory consolidation, attention, and decision-making processes, which are crucial for optimal athletic performance. Furthermore, quality sleep supports mental health by reducing stress, anxiety, and depressive symptoms, improving overall emotional resilience (Kawasaki et al., 2020).

Paralympic athletes tend to report poor sleep quality, as well as poor sleep habits and insufficient sleep duration. Symptoms of insomnia, nighttime awakenings, sleep movements, and poor sleep quality have been associated with the onset and severity of health problems (Silva et al., 2022). Athletes, coaches, and healthcare professionals with disabilities must recognize the importance of rest and sleep in recovery. By prioritizing adequate rest and creating an optimal sleep environment, athletes with disabilities can promote physical and mental recovery, improve performance, and support their overall well-being.

Incorporating rest periods and ensuring quality sleep can be key factors in maximizing recovery and maintaining long-term athletic success for athletes with disabilities (Durán Agüero et al., 2015).

To improve sleep quality, it is recommended to establish regular, consistent sleep routines, including set bedtimes and wake times. Additionally, maintaining a suitable sleep environment, with optimal temperature, low light, and reduced external noise, has been shown to promote better sleep. Furthermore, it is suggested to avoid stimulants such as caffeine and nicotine, especially before bed, as they can interfere with sleep. Practicing relaxation techniques, such as meditation and deep breathing, can also facilitate sleep. Additionally, limiting screen time before bed has been shown to help regulate circadian rhythms and improve sleep quality in Paralympic athletes (Durán Agüero et al., 2015; Grade et al., 2023; Roberts et al., 2021; Silva et al., 2022).

Nutrition, hydration, and supplementation

When evaluating the performance of athletes with disabilities, nutritional methods are crucial. Identifying the necessary nutritional solutions, taking into account the nature of the disability and the specific sport, is vital (Yokoyama et al., 2022). Despite this, athletes with disabilities have less knowledge of sports nutrition and often hold misconceptions related to poor habits (Deguchi et al., 2021; Rastmanesh et al., 2007). Among the most commonly used nutritional strategies by athletes with disabilities are carbohydrate and protein supplementation, sports drinks, and multivitamins (Graham-Paulson et al., 2015). These supplements have been combined with electrolytes and vitamin D in sports such as wheelchair rugby (Madden et al., 2018).

There is a research gap regarding the precise dietary requirements that athletes with disabilities must meet to perform at their best. Applying dietary practices used by able-bodied athletes to athletes with disabilities requires caution. Nutrition is a key factor in the recovery process for athletes with disabilities. Understanding the specific nutritional considerations and recommendations can help promote optimal recovery and improve performance in this population (Islamoglu & Kenger, 2019). Protein is essential for muscle repair and recovery. Athletes with disabilities must ensure adequate intake of high-quality protein sources to support tissue repair and adaptation (Jeoung & Kim, 2021). Recommended protein intake can vary depending on factors such as the type and severity of the disability, training intensity, and goals (Flueck, 2021). A general guideline is to aim for 1.2–2.0 grams of protein per kilogram of body weight per day (Kerksick et al., 2018).

The main source of energy during physical activity is carbohydrates, which play a vital role in replenishing glycogen stores. Athletes with disabilities should focus on consuming carbohydrates before, during, and after training or competition to optimize glycogen restoration (Flueck, 2021). The specific amount and timing of carbohydrate intake can vary with individual factors, including disability type, training duration, and intensity. It is common for athletes with disabilities to report lower than required intake (Goosey-Tolfrey & Crosland, 2010). Adequate hydration is essential for optimal recovery. Athletes with disabilities must ensure adequate fluid intake before, during, and after exercise to maintain hydration levels (Flueck, 2021). Factors such as the rate of sweating, the duration and intensity of the activity, and environmental conditions are variables that determine the amount of fluid required. Monitoring hydration status and adjusting fluid intake accordingly is crucial to promoting adequate recovery (Broad, 2001).

Athletes with disabilities may have specific micronutrient needs due to their disabilities or medical conditions. It should also be considered that micronutrient deficiencies are common among athletes with disabilities (Sasaki & da Costa, 2021). Additionally, they often do not meet the requirements for vitamins D and E, potassium, magnesium, and pantothenic acid (Madden et al., 2017). Individualized consideration should be given to factors such as calcium, vitamin C, B6, B12, and vitamin D intake for individuals with spinal cord injuries to support bone health (Jeoung & Kim, 2021).

Incorporating foods with anti-inflammatory properties can aid recovery by reducing exercise-induced inflammation. Including foods rich in omega-3 fatty acids, such as fatty fish, flax seeds, and walnuts, as well as a variety of fruits, vegetables, and whole grains, provides beneficial antioxidants and phytochemicals that support the body's natural healing process (Das et al., 2019; Scaramella et al., 2018).

Proper nutrition is essential for optimizing the recovery process in athletes with disabilities. Adequate protein intake, appropriate timing and amount of carbohydrates, hydration management, consideration of specific micronutrient needs, and the inclusion of anti-inflammatory foods are important considerations (Islamoglu & Kenger, 2019). It is common for athletes with disabilities not to meet basic or optimal requirements for competition (Hertig-Godeschalk et al., 2023). Furthermore, these athletes often report deficiencies in their body composition and bone density (Cavedon et al., 2021). A personalized approach, guided by a registered dietitian or healthcare professional, can help develop an individualized nutrition plan to support the unique needs and goals of athletes with disabilities during their recovery.

Metabolism and muscle damage

Muscle metabolism and damage recovery are essential aspects of the overall recovery process in athletes with disabilities. The unique challenges faced by athletes with disabilities, such as altered muscle activation patterns and impaired sensory feedback, can affect muscle metabolism and the recovery timeline (Fischer et al., 2020). Understanding the mechanisms underlying muscle metabolism and damage repair in athletes with disabilities is critical for developing targeted interventions that optimize recovery and enhance performance.

Regarding athletes with disabilities, the available information is highly heterogeneous and of poor quality. For example, there is no information on the severity of injuries, athletes' ages, or descriptions of their disabilities (Fagher & Lexell, 2014; Weiler et al., 2016). These injuries, caused by training or competition, often last from 7 days (52%) to more than 22 days (22%; Ferrara & Peterson, 2000). Furthermore, pain is a factor present in more than 50% of athletes with disabilities, preventing them from performing optimally (Bernardi et al., 2003). This highlights the particular need to develop recovery strategies for athletes with disabilities.

The impact of injuries on athletes with disabilities varies significantly depending on the type of disability and must be considered for muscle and metabolic recovery. Injury patterns have been identified in different groups of athletes with disabilities. Wheelchair athletes tend to suffer upper limb injuries, blind athlete's lower limb injuries, and athletes with cerebral palsy may have injuries to both. Spasticity and deformities in athletes with cerebral palsy often lead to knee and foot injuries. Amputee athletes may suffer injuries to the stump, spine, and remaining limbs, while blind athletes suffer lower limb injuries. Finally, athletes with intellectual disabilities may have visual impairments, heart problems, and cervical instability that make them prone to injury (Klenck & Gebke, 2007).

Muscle metabolism plays a central role in supplying energy for muscle contraction and facilitating recovery. Athletes with disabilities may exhibit differences in muscle metabolism due to the nature of their disabilities and altered muscle activation patterns. For example, wheelchair athletes exhibit reductions in aerobic and anaerobic capacity that correlate with the severity of spinal cord injury (Fischer et al., 2020). These alterations can affect the utilization of different energy substrates, such as carbohydrates and fats, during exercise and recovery. Research suggests that individuals with certain disabilities, such as spinal cord injuries, may experience metabolic adaptations, including lower resting energy expenditure and altered fuel utilization. Further research is needed to elucidate the specific metabolic adaptations across different types of disabilities and their implications for muscle recovery.

Muscle damage occurs during intense or prolonged exercise and is an inherent part of the training process (Assumpção et al., 2013). Factors such as altered muscle activation patterns, compromised sensory feedback, and increased mechanical stress on certain muscle groups can contribute to muscle damage in athletes with disabilities. Recovery from damaged muscle involves processes such as inflammation, regeneration, and remodeling. Research on muscle damage and repair in athletes with disabilities is limited. Still, existing evidence suggests that adaptations in muscle structure and function can occur, albeit in patterns different from those observed in able-bodied athletes.

For example, intermittent pneumatic compression has been suggested to provide some benefits for measures of perceptual recovery immediately after and 24 hours after intense wheelchair activity, with negligible effects on performance recovery (Oliver & Driller, 2021).

Furthermore, significant differences in muscle stiffness following therapeutic massage have been found in cyclists (Kennedy et al., 2018).

Several factors can influence muscle recovery in athletes with disabilities. First, the type and severity of the disability can affect muscle metabolism and the extent of muscle damage, thereby influencing the recovery timeline. Second, training load and intensity play a critical role in muscle recovery, making appropriate training progressions and periodization essential. Furthermore, age and overall health status, including comorbidities or medical conditions, can influence muscle recovery capacity in athletes with disabilities. It is important to consider these factors when designing training and recovery strategies to promote effective muscle recovery and minimize the risk of overtraining or injury (Webborn & Emery, 2014).

Additionally, considering the high rate of injuries, prevention strategies must be developed. Emphasis can be placed on risk behaviors, normalized pain, functional limitations, overuse injuries, psychological stressors, access to services, and other factors to avoid adverse physical, physiological, and mental health events (Fagher et al., 2016).

Emotion and cognition

Athletes with disabilities may face a range of challenges that can have a disproportionate impact on their mental health compared to elite athletes in general, according to the International Olympic Committee (Reardon et al., 2019; Swartz et al., 2019). Some of these stressors can affect athletes in general, but others are unique to those with disabilities (Macdougall et al., 2015). Factors such as emotional regulation, lack of purpose outside of sport, the nature of the disability, interaction with pain, and lack of self-acceptance are key determinants of athletes' emotional and cognitive well-being (Macdougall et al., 2016). Furthermore, the condition of disability places these athletes in a vulnerable position from a mental health perspective (Vertommen et al., 2015).

One common stressor is chronic pain, which can be both physical and emotional. Athletes with disabilities often experience injuries and complex medical conditions, making it difficult to distinguish between athletic fatigue, discomfort caused by their disability, and sports injuries. This confusion can lead to additional anxiety and stress (Tuakli-Wosornu et al., 2018; Walter & Krassioukov, 2018). The lack of sufficiently adapted sports facilities and access to services can also be a significant stressor. Paralympic athletes rely on suitable facilities and adapted equipment to train and compete, and a lack of access to these resources can lead to frustration and limit their performance (Bantjes & Swartz, 2018). The logistical challenges associated with traveling to competition venues can also generate additional stress. Organizing travel can be more complex for athletes with disabilities, as it requires coordinating medical and support teams and adapting to each athlete's specific needs during the trip (Reardon et al., 2019).

Challenging sleep conditions and poor sleep quality in Paralympic Villages can also affect athletes' mental recovery (Silva et al., 2022). Adequate rest is critical for performance and mental health, and when it is not achieved, it can increase anxiety and stress.

The increasing competitiveness of Paralympic sport and the associated training demands are also significant stressors. Athletes must cope with ever-increasing levels of competition and adapt quickly to changes in the sport. This can create additional pressure and require greater adaptability (Reardon et al., 2019; Swartz et al., 2019).

Other stressors include poorly functioning sports equipment, the costs associated with acquiring new technology, negative coaching behaviors such as demeaning comments, and the possibility of being misclassified or assigned to the wrong disability category for competition (Reardon et al., 2019; Swartz et al., 2019).

Additionally, lack of transportation, inadequate coach training, negative experiences with support staff, and other factors worsening the mental health of these athletes. All of these factors can contribute to anxiety, frustration, and loss of motivation in athletes with disabilities (Asken, 1991).

To better understand the relationship between these stressors and the mental health of Paralympic athletes, it is important to conduct studies that investigate their impact. This will help to understand the causes of mental health symptoms and disorders in this population and to develop interventions to counteract and manage these symptoms effectively and appropriately.

The recovery of Paralympic athletes from stress, anxiety, and emotional challenges involves implementing a variety of methods. To reduce stress, relaxation techniques such as deep breathing and visualization are recommended. Mindfulness and meditation are also effective tools for managing anxiety. A strong social support system, cognitive behavioral therapy, and overall well-being through self-care are also essential. Finally, educational programs provide tools and strategies for emotion regulation. By implementing these approaches, athletes can strengthen their mental well-being and improve their athletic performance.

Future lines of research

In the context of recovery strategies for athletes with disabilities, specifically in football, several challenges must be addressed for future interventions and practical applications. One of these challenges is the need for more research and evidence. Further studies are required to explore and validate the effectiveness of specific recovery strategies in the context of football for athletes with disabilities; very little information is currently available in this area. These research efforts could focus on examining physiological and psychological responses to various recovery interventions and evaluating their effects on performance, injury prevention, and overall well-being.

Another challenge is ensuring equitable access to resources and opportunities for athletes with disabilities. It is important to provide equal access to specialized equipment, adaptive technologies, and trained healthcare professionals. This requires addressing accessibility gaps across regions and organizations and providing the necessary resources for athletes to optimize their recovery. Individualization and personalization are also key challenges. Each athlete with a disability has unique needs and considerations, and recovery strategies must be tailored to meet their individual requirements, disabilities, and performance goals. This may involve a multidisciplinary approach, engaging coaches, trainers, rehabilitation specialists, and healthcare professionals who understand the specific challenges faced by soccer players with disabilities (Wareham et al., 2017).

The integration of technology presents both an opportunity and a challenge for the future. Advances in wearable devices, mobile apps, and data analytics offer valuable information that contributes to an athlete's recovery, the necessary workload during training, and the risk of injury. Leveraging technology in recovery programs can help monitor and optimize the recovery process, as well as facilitate communication and collaboration among athletes, coaching staff, and healthcare professionals.

Finally, education and awareness are crucial for this population, as they have proven effective in changing conditions, attitudes, and therefore overall physical, physiological, and mental performance (Tam et al., 2019). It is essential to increase knowledge and awareness among coaches, strength and conditioning coaches, and healthcare providers regarding the unique recovery needs of athletes with disabilities. This includes disseminating information on effective recovery strategies, adaptive techniques, and inclusive approaches. Collaboration among stakeholders is necessary to create an inclusive and supportive environment that prioritizes the recovery needs of soccer players with disabilities.

Addressing these future challenges will contribute to the advancement of recovery strategies for athletes with disabilities. By focusing on research, accessibility, individualization, technological integration, and education, we can improve the recovery process, promote optimal performance, and enhance the overall well-being of athletes with disabilities. Furthermore, given the current evidence on recovery measures and strategies, it is important to investigate recent proposals (see Figure 2), their effectiveness, and accessibility—key aspects in adapted sports.

Figure 2

Proposal of potential recovery methods and their effectiveness or detriment, adapted from Tierney (2023) and oriented by the domains proposed by Calleja-González et al. (2021).

Conclusions

In conclusion, implementing appropriate and personalized recovery strategies is essential to maximizing performance and promoting the health of athletes with disabilities. The individualized nature of disabilities requires a holistic approach that considers each athlete's specific needs. Taking into account factors such as the type and severity of the disability, training load and intensity, and age and overall health helps in designing effective recovery plans.

In summary, understanding and applying appropriate recovery strategies in adaptive sports is essential for optimizing the performance and well-being of athletes with disabilities. By tailoring recovery strategies to the specific disciplines of adaptive sports and considering athletes' individual needs, effective recovery, improved performance, and a positive sporting experience can be ensured.

Ethical approval

Not applicable. This study is a secondary analysis of previously published data and does not involve direct human participation. Therefore, ethical approval was not required.

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Conflict of interest

The authors declare no conflict of interest.

Availability of data and materials

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Consent for publication

Not applicable. This study did not involve personal data from individuals, and no consent was required for publication.

Statement on the use of artificial intelligence

Artificial intelligence tools were used to improve text flow and to make minor grammatical and stylistic corrections. The authors reviewed and edited all content and took full responsibility for the manuscript's accuracy, originality, and integrity.

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