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INVESTIGATION OF THE MAIN MUSCULOSKELETAL SHOULDER INJURIES IN SWIMMERS AND PREVENTION PROPOSALS: A NARRATIVE REVIEW

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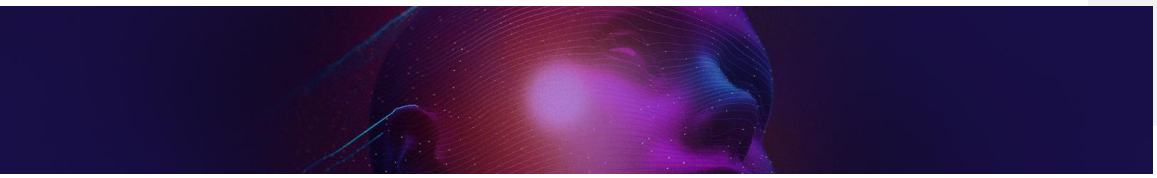
Gabriella Bulgarelli de Souza[a], Gustavo Damaceno Giglini[a], Daniel Vicentini de Oliveira[b]*, Eduardo Quadros da Silva[c]

Cidade Verde University Center, Maringá – PR, Brasil[a]
State University of Maringá, Maringá – PR, Brasil[b]
Cesumar University, Maringá – PR, Brasil[c]
****E-mail: d.vicentini@hotmail.com***

ABSTRACT

Swimming requires significant effort from the shoulders, which are responsible for up to 90% of propulsion, thereby increasing the risk of musculoskeletal injuries due to muscular imbalances and overload. Physical therapy plays a crucial role in preventing and treating these injuries, ensuring swimmers' health and performance. This study aimed to investigate the most common musculoskeletal shoulder injuries among swimmers and the proposed prevention strategies. This is a narrative review, based on previously published scientific articles on the topic. The search was carried out in the PubMed and Scielo databases from February to September 2024. Out of a total of 13.225 articles, after title analysis and application of inclusion and exclusion criteria, 10 articles were included in this review. Strategies such as elastic bands, neuromuscular electrical stimulation, taping, and exercises in open- and closed-chain formats were effective in improving muscle torque and reducing pain. These interventions are crucial for both preventing and rehabilitating shoulder musculoskeletal injuries in swimmers.

Keywords: Swimmers; Shoulders; Injuries.



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INTRODUCTION

Swimming stands out due to the significant demand it places on the shoulders and upper limbs, which generate up to 90% of the propulsive force during practice (De Martino & Rodeo, 2018). The activity requires exceptional mobility, including complex movements such as multidirectional rotations and scapular motions (Batalha *et al*., 2019), supported by the intricate coordination of joints such as the glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic (Moradi *et al*., 2019).

The rotator cuff—composed of the supraspinatus, infraspinatus, teres minor, and subscapularis—plays a central role in stabilizing the shoulder and preventing injuries during swimming (Della *et al*., 2023; Moradi *et al*., 2019). Due to overload and repetitive movements, swimmers are particularly vulnerable to shoulder injuries, highlighting the need to understand injury mechanisms and develop effective preventive strategies (Tooth *et al*., 2020).

Musculoskeletal injuries in swimmers are associated with muscular imbalances, joint instability, and overuse (Wirth *et al*., 2022; Tavares *et al*., 2022; Smith, Hotze, & Tate, 2021). Common issues include internal/external rotator imbalances, scapular dyskinesis, glenohumeral instability, ROM deficits, and muscle weakness (Tavares *et al*., 2022; Della Tommasina *et al*., 2023). Reported conditions include "swimmer's shoulder", impingements, tendinitis, rotator cuff injuries, and joint instability (Boltz *et al*., 2021; Bona *et al*., 2022; Handson, Ostrem, & Davies, 2019).

These injuries affect not only performance but also daily life and quality of life (Smith, Hotze, & Tate, 2021). Studies have shown a link between competitive swim training and increased injury risk. Dischler *et al*. (2018) found that 69% of swimmers had MRI evidence of supraspinatus tendinopathy, and all reported pain related to tendon overload.

This alarming incidence of injuries underscores the need to comprehend the underlying mechanisms and develop effective prevention and rehabilitation strategies. Additionally, it is crucial to evaluate the impact of these injuries on athletes' lives, not only on sports performance but also on their overall quality of life (Dischler *et al*., 2018).

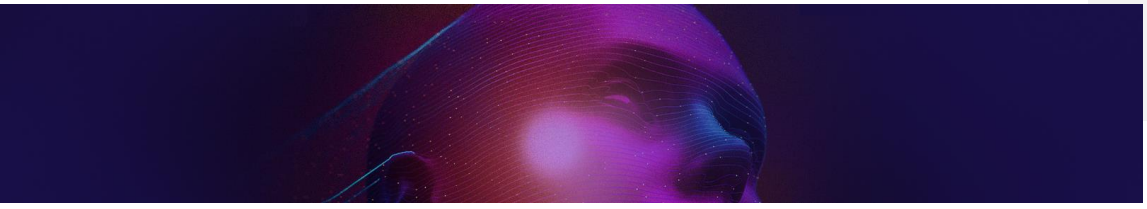
Shoulder injuries in swimmers are typically associated with the high volume of repetitive overhead movements required during training and competition. These repetitive actions increase mechanical stress on the glenohumeral joint and surrounding structures, predisposing athletes to overuse injuries. Among the most frequently reported mechanisms are muscular imbalances between internal and external rotators, scapular dyskinesis, reduced rotator cuff strength, and deficits in shoulder range of motion (Feijen *et al*., 2020; Tooth *et al*., 2020).

Additionally, alterations in glenohumeral stability and rotator cuff function may contribute to conditions commonly described as "swimmer's shoulder," including subacromial impingement, tendinopathies, and rotator cuff injuries. These mechanisms are often exacerbated by high training loads and inadequate recovery, leading to progressive overload of shoulder structures (De Martino & Rodeo, 2018; Feijen *et al*., 2020). Understanding these mechanisms is essential for developing effective preventive strategies to reduce injury risk and improve shoulder function in swimmers.

Physical therapy plays a crucial role in swimming, both in preventing and treating shoulder injuries and in strengthening the muscles involved in the sport. Current studies demonstrate several preventive strategies, including a comprehensive protocol that uses neuromuscular electrical stimulation (NMES), taping, strengthening, and stretching to address common deficiencies among swimmers (Smith *et al*., 2021). In addition to this protocol, other techniques have been explored, such as compensatory strength training programs using Therabands and flexibility routines (Batalha *et al*., 2020).

Although previous reviews have investigated risk factors for shoulder pain in swimmers and overhead athletes (McKenzie *et al*., 2023; Hill, Collins, & Posthumus, 2015), many focus primarily on training load, biomechanical factors, or isolated therapeutic exercises. In addition, the available literature often addresses injury mechanisms or rehabilitation strategies separately. However, there remains a need for an integrated synthesis that focuses specifically on physiotherapeutic prevention strategies for swimmers, combining evidence on strengthening, neuromuscular training, and recovery approaches applicable to clinical and sports practice.

Comentado [DV1]: Hill L, Collins M, Posthumus M. Risk factors for shoulder pain and injury in swimmers: A critical systematic review. Phys Sportsmed. 2015 Nov;43(4):412-20. doi: 10.1080/00913847.2015.1077097. Epub 2015 Sep 14. PMID: 26366502.



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In light of this evidence, investigating preventive physiotherapeutic strategies for shoulder injuries in swimmers becomes essential, not only to minimize injury risk but also to optimize performance and promote long-term athlete health. Therefore, this review aimed to synthesize the main musculoskeletal shoulder injuries reported in swimmers and to describe physiotherapeutic prevention strategies proposed in the literature, integrating evidence on strengthening, neuromuscular training, and recovery approaches used to reduce shoulder overload in competitive swimming.

METHODS

This research was conducted as a narrative literature review based on previously published scientific articles on the topic. This review was designed as a narrative review to provide a broad synthesis of the literature on shoulder musculoskeletal injuries in swimmers and the preventive physiotherapeutic strategies reported across different study designs. Unlike systematic or integrative reviews, which typically aim to answer highly specific research questions and include formal methodological quality assessment and quantitative synthesis, the present study sought to summarize and interpret evidence from heterogeneous interventions and study designs to provide a comprehensive overview of the topic.

The selected keywords were controlled descriptors retrieved from the Health Sciences Descriptors (DeCS) platform and listed along with their respective MeSH terms, as shown in Table 1. The search strategy combined descriptors related to swimmers, shoulder injuries, and prevention strategies, including “swimmers”, “shoulder injuries”, “rotator cuff”, “swimmer’s shoulder”, and “prevention”. These descriptors were combined using Boolean operators (AND/OR) and adapted to each database's indexing system.

The search was carried out in the PubMed and SciELO databases between February and September 2024. The criteria for study selection included full-text studies published in Portuguese, English, or Spanish between 2018 and 2024 in indexed journals, regardless of study design, that involved swimmers or populations engaged in competitive swimming and addressed shoulder musculoskeletal injuries or preventive/rehabilitative physiotherapeutic strategies. Duplicate records, incomplete studies, articles unrelated to the topic, and publications that did not meet the inclusion criteria were excluded.

After the selection of studies, the relevant data were organized and tabulated using Microsoft Excel 2016 spreadsheets. The screening process involved an initial reading of titles and abstracts, followed by a full-text analysis of potentially eligible articles. This process was conducted independently by two reviewers. Any disagreements regarding study inclusion were discussed until consensus was reached.

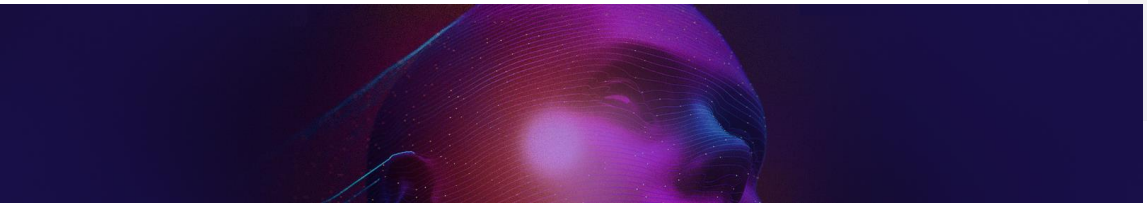
As this study was designed as a narrative review, no formal methodological quality assessment tool was applied to the included studies. However, the studies were critically analyzed with respect to their design, intervention characteristics, and reported outcomes.

RESULTS

The search for studies published between February and September 2024 yielded 13,225 articles, of which 12,194 were from PubMed and 1,031 from Scielo. After title analysis to check for duplicates and the application of the pre-established inclusion and exclusion criteria, a total of 10 articles were included in this review.

Table 1. Articles included in the review on musculoskeletal shoulder injuries in swimmers and prevention strategies, from 2018 to 2024.

Author/Year	Injury	Intervention period	Prevention strategies	Results
BOLTZ *et al*., 2021.	Biceps tendinitis; Shoulder impingement; Rotator cuff tear; Rotator cuff tendinitis.	Study of exposure and injury data in men’s swimming and diving collected in the NCAA ISP from the 2014–2015 through the 2018–2019 athletic seasons.	It proposes the practice of high-intensity interval training (HIIT), involving repeated short-to-long duration sessions of high-intensity exercise interspersed with recovery	HIIT has been shown to increase muscle mass, reduce shoulder pain, prevent musculoskeletal shoulder injuries, and improve athletic performance in swimming.



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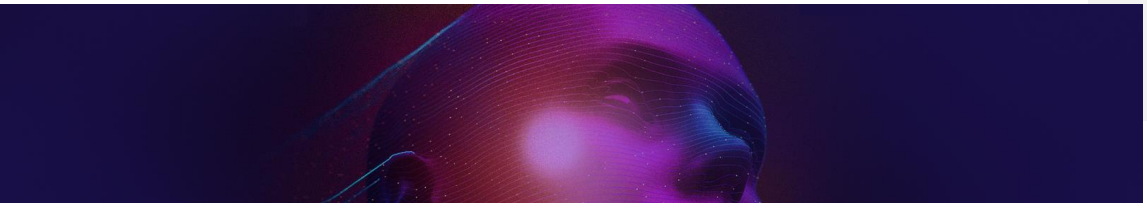
Author/Year	Injury	Intervention period	Prevention strategies	Results
			periods.	
DELLA TOMMASINA *et al*., 2023.	Imbalance of: shoulder internal and external rotators; shoulder adductors and abductors.	A prospective, longitudinal, randomized, controlled, single-masked clinical trial lasting 8 weeks, following CONSORT guidelines; training at least 2 days per week.	Kabat diagonal exercise using elastic bands; training of the shoulder external rotators to prevent rotator cuff injuries in swimmers due to the high incidence of these injuries and the biomechanical importance of the rotator cuff during the sport-specific movement.	Strength training improved the isometric strength of the external rotator muscles and the balance between shoulder rotators, although the changes were not significant ($p > 0.05$). There were also gains in rotational capacity and rotator cuff strength with the use of elastic bands and the Kabat pattern.
BATALHA, N. *et al*., 2020.	Injury to the shoulder rotators; Glenohumeral joint instability.	All swimmers performed three sets of 20 repetitions of each exercise, with a 30-second rest interval between repetitions and a one-minute rest interval between exercises. A high number of repetitions was used to meet the specificity of swimming, which requires muscular endurance capacity, and to achieve greater activation of the rotator cuff muscles.	Compensatory strength training program using a theraband, applying four specific exercises: (1) shoulder press; (2) shoulder external rotation with the arm abducted at 90°; (3) shoulder flexion; (4) low scapular rows at 45° of flexion.	Compensatory strength training did not cause significant changes in strength or the ER/IR ratio, in either the dominant or non-dominant shoulder, at speeds of 60º/s and 180º/s. The variations were trivial, with no signs of fatigue.
TAVARES *et al*., 2022.	Glenohumeral instability; Scapular dyskinesis; Muscle weakness; Range of motion (ROM) deficit.	A six-week training program, performed 2 to 3 times per week, with progressive overload over time.	Shoulder strengthening, endurance, and stretching exercises. Unfortunately, the authors did not specify which muscles were involved in this process.	Strength programs showed significant positive effects in the experimental group, especially in maximal ER strength. Combined strength and stretching programs did not lead to changes in strength and endurance variables. However, programs performed out of the water, with open-kinetic-chain exercises, resulted in greater improvements in strength and endurance.
BATISTA, *et al*., 2024.	Muscular pain.	The study lasted 6 weeks, divided into baseline weeks and intervention weeks.	Cold water immersion (CWI) after resistance training, compared to thermoneutral water immersion (TWI) and passive recovery (PAS).	When applied during training sessions, no performance impairments were observed, and athletes felt more recovered after performing CWI or TWI compared to PAS. However, repeated use of CWI over a week of training did not impact the functional or swimming performance outcomes of competitive adolescent swimmers.
HANSON; OSTREM; DAVIES, 2019.	Subacromial pain.	Application of KT for 30 minutes.	They performed functional shoulder flexion movements and evaluated the shoulder using the Disabilities of the Arm, Shoulder, and Hand	There was a significant change in functional movement assessment scores and pain and disability scores (2.17) after KT application. KT



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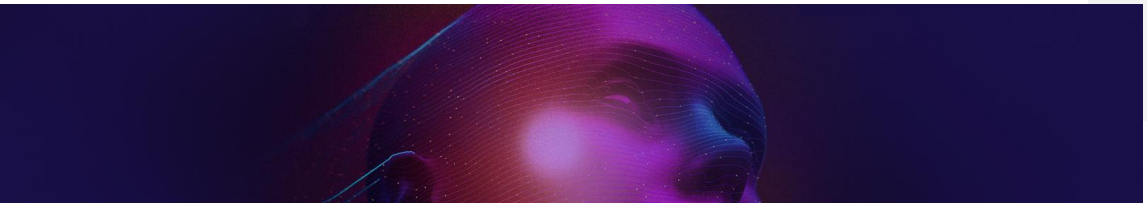
Author/Year	Injury	Intervention period	Prevention strategies	Results
			(DASH) index before and 30 minutes after KT application (kinesiology taping).	significantly reduced shoulder pain and improved active functional movement in swimmers.
SMITH *et al*., 2021.	Muscle imbalances; Infraspinatus weakness and failure of voluntary activation (FVA); Pain.	Sessions of approximately 60 minutes, twice a week for eight weeks.	Protocol using neuromuscular electrical stimulation (NMES), taping, strengthening, and stretching to address common deficiencies among swimmers.	The authors found that combining modifications to land-based and in-water training, along with NMES and taping to complement a strengthening and stretching program, facilitated the return of competitive swimmers to their pre-injury performance levels.
MORADI; RAHNAMA; SALEHI, 2019.	Subacromial impingement syndrome.	Training was conducted three times a week for eight weeks.	Intervention carried out over 8 weeks, including open kinetic chain exercises (external rotation, internal rotation, dumbbell curl, and reverse dumbbell curl) and closed kinetic chain exercises (push-up, scapular push-up, scapular dip, and crab walk) performed at angles of 60, 80, and 120 degrees per second.	Open- and closed-chain exercises improve the torque of the shoulder's internal and external rotator muscles and are therefore recommended for both prevention and rehabilitation strategies.
BONA *et al*., 2023.	Swimmer's shoulder pain.	Intervention program lasting 12 weeks.	Twelve-week intervention with exercises performed twice a week, each session lasting 50 minutes. Exercises included elastic band work and scapular stability exercises.	The intervention was effective, as evidenced by reductions in shoulder pain on the Patte, Hawkins, Palm-up, Jobe, and Lift-off tests. It is concluded that strength training is highly recommended to enhance swimmers' performance, reduce injury risk, and alleviate pain intensity.
WIRTH, *et al.* 2022.	Subacromial or intra-articular impingement; Reduced glenohumeral stability.	This refers to a specific and semi-specific strength training program, without a precise intervention period being measured.	Strength training.	Strength training has been proven effective in increasing maximal strength and muscle mass, improving joint impact distribution, and reducing pain. In the long term, increasing maximal strength is fundamental for enhancing power and athletic performance.

DISCUSSION

The findings of this review reinforce the importance of targeted strength and conditioning programs, combined with complementary physiotherapeutic strategies, in preventing and managing shoulder musculoskeletal injuries among swimmers. Most of the included studies indicate that interventions focusing on shoulder strengthening, neuromuscular control, and joint stability can contribute to pain reduction, functional improvement, and enhanced athletic performance.

Overhead sports, such as swimming, involve repetitive upper-limb movements above shoulder level, which increase mechanical stress on the glenohumeral



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joint. These demands are associated with overload, muscular imbalance, and reduced strength of the external rotators relative to the internal rotators, factors commonly associated with shoulder pain in swimmers (Tooth *et al*., 2020). Consequently, preventive programs frequently emphasize restoring muscular balance and improving shoulder stability.

Strength training appears to be one of the most consistently reported strategies in the literature. Studies investigating land-based exercise programs demonstrated improvements in muscle strength, shoulder stability, and functional performance. Both open and closed kinetic chain exercises have been associated with increases in rotator muscle torque and improvements in neuromuscular control, which are essential for reducing the mechanical stress generated by repetitive swimming strokes (Moradi *et al*., 2019; Wirth *et al*., 2022).

Several studies also investigated strengthening programs using elastic resistance, including exercises based on the Kabat diagonal pattern. These interventions aim to improve rotator cuff function and correct the imbalance between internal and external rotators commonly observed in swimmers. Although some studies did not report statistically significant improvements in strength variables, small gains in rotational capacity and shoulder stability were observed, suggesting that these exercises may contribute to injury prevention when integrated into regular training routines (Batalha *et al*., 2020; Della Tommasina *et al*., 2023).

However, the results of strengthening interventions were not entirely consistent across studies. While some protocols reported improvements in torque, muscle balance, and pain reduction, others did not demonstrate statistically significant differences. These discrepancies may be related to methodological factors, such as a short intervention duration, small sample sizes, a limited number of exercises, and a lack of supervision during training sessions. In addition, differences in exercise specificity and testing positions may influence the responsiveness of strength outcomes, particularly when protocols do not closely replicate the functional demands of swimming.

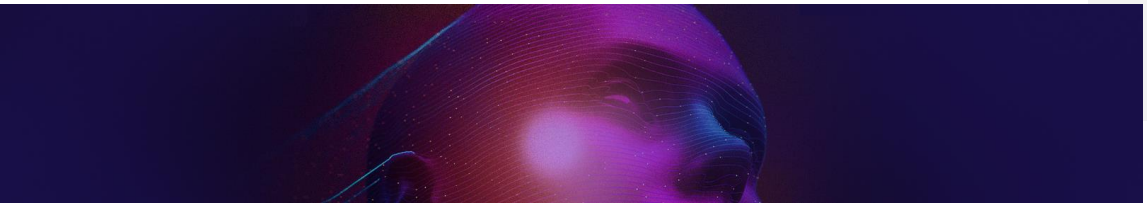
Additional strategies have also been explored to complement strengthening programs. Neuromuscular electrical stimulation (NMES), taping techniques, and modifications to both land-based and water-based training have been described as approaches that can improve muscle activation, reduce pain, and facilitate return to sport (Smith *et al*., 2021). Taping techniques, including Kinesio Taping, may improve scapular positioning, proprioception, and shoulder function, thereby supporting stroke mechanics and reducing discomfort during training (Hanson *et al*., 2019).

Some interventions have focused on recovery and training modulation. High-intensity interval training (HIIT) has been suggested as a training strategy that can improve physical conditioning while promoting muscular adaptation and injury prevention (Boltz *et al*., 2021). Additionally, cold water immersion has been investigated as a recovery method between training sessions, showing positive subjective effects on recovery without impairing athletic performance (Batista *et al*., 2024).

It is important to note that the level of evidence supporting some of these complementary strategies remains limited. For example, studies investigating taping techniques and neuromuscular electrical stimulation often involve small samples or exploratory designs, which restricts the generalization of their findings. Similarly, evidence on HIIT and cold-water immersion in swimmers is still emerging, with some studies reporting benefits for recovery or conditioning but lacking detailed intervention protocols or long-term follow-up. Therefore, while these strategies appear promising, further controlled studies with larger sample sizes and standardized protocols are necessary to establish their effectiveness more definitively.

Strengthening programs performed out of the water also appear to play an important role in injury prevention. Programs emphasizing shoulder strengthening, endurance, and scapular stability have demonstrated reductions in shoulder pain and improvements in muscle function among swimmers (Bona *et al*., 2023; Tavares *et al*., 2022). These findings highlight the importance of integrating land-based conditioning with swimming training to reduce musculoskeletal overload.

Overall, the literature suggests that preventive physiotherapeutic strategies for swimmers should focus on strengthening the rotator cuff, improving muscular balance, enhancing scapular stability, and optimizing neuromuscular control. When combined with appropriate training management and recovery strategies, these



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approaches may help reduce injury risk and support long-term athletic performance.

This study presents some limitations. The restriction of databases and languages may have reduced the scope of the search, and the temporal cut-off may have excluded relevant studies. Additionally, the absence of a meta-analysis and a formal quality assessment limits the strength of the conclusions. The heterogeneity of interventions and study populations also restricts the generalizability of the findings.

CONCLUSION

This narrative review highlights the strong association between swimming and shoulder musculoskeletal injuries, largely due to the repetitive overhead movements and high mechanical demands placed on the glenohumeral joint. Across the studies included in this review, some findings appear relatively consistent, particularly the role of muscular imbalances between internal and external rotators, scapular dyskinesis, and shoulder instability as important contributors to shoulder pain and dysfunction in swimmers.

Among preventive strategies, strengthening programs targeting the rotator cuff and scapular stabilizers—especially those performed out of the water and including open- and closed-chain exercises—showed the most consistent benefits across studies. These interventions were frequently associated with improvements in muscle torque, shoulder stability, and reductions in pain symptoms. Complementary approaches such as elastic resistance exercises, neuromuscular electrical stimulation, taping techniques, and structured strength programs may also contribute to injury prevention and rehabilitation when integrated into regular training routines.

However, some findings remain inconclusive due to the limited number of studies, small sample sizes, heterogeneous protocols, and short intervention durations. Evidence regarding complementary strategies such as high-intensity interval training (HIIT), cold water immersion (CWI), and taping remains promising but still limited, requiring further investigation through controlled clinical trials with standardized protocols.

From a practical perspective, preventive programs for swimmers should prioritize strengthening of the rotator cuff, improving muscular balance between internal and external rotators, enhancing scapular stability, and incorporating land-based conditioning exercises that complement swimming training. Individual assessment of each athlete's functional demands and training load is also essential for optimizing rehabilitation strategies and reducing injury risk.

Finally, future studies should aim to standardize intervention protocols, increase sample sizes, and improve methodological rigor to strengthen the evidence base on preventive physiotherapeutic strategies for shoulder injuries in swimmers.

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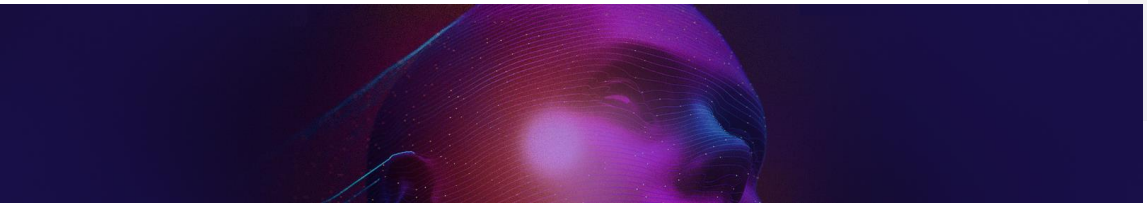

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