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Prevention of rotator cuff overuse injuries in youth swimmers

Prevención de lesiones por sobreuso del manguito rotador, en nadadores juveniles

Prevenção de lesões por sobrecarga do manguito rotador em nadadores jovens

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ABSTRACT

This article aimed to characterize the current state of the rotator cuff overuse injury prevention process in a sample of high-performance youth swimmers as an initial phase for designing a specific methodology. A descriptive study with a mixed-methods approach was conducted on a purposive sample of athletes and coaches from the "Pedro Téllez Valdés"



Provincial Swimming Academy in Pinar del Río. Theoretical methods included document analysis; empirical methods included observation, semi-structured interviews, and surveys; and measurement methods included palpation, the Neer test, ultrasound, the Y-strength test, the specific resistance test, and the visual analog scale for pain. The results obtained during the diagnostic process revealed that 80% of the athletes presented glenohumeral joint pain during the physical examination, and differential diagnostic tests confirmed alterations such as tendinitis and myositis in 80% of the sample. It was found that the institutional prevention plan was descriptive and did not address the systematic identification of risk factors, with insufficient application of active recovery methods such as cryotherapy and sports massage; a high prevalence of injury symptoms and significant deficiencies in the prevention process were found, which showed the need to develop and implement a methodology, with the integration of periodic screening, specific strengthening and advanced recovery strategies to mitigate the risk of overuse injuries.

Keywords: high-performance athletes, diagnosis, rotator cuff, swimming, injury prevention

RESUMEN

El presente artículo tuvo como objetivo caracterizar el estado actual del proceso de prevención de lesiones por sobreuso del manguito rotador, en una muestra de nadadores juveniles de alto rendimiento como fase inicial para el diseño de una metodología específica. Se realizó un estudio descriptivo con enfoque mixto en una muestra intencional de atletas y entrenadores de la Academia Provincial de Natación "Pedro Téllez Valdés", de Pinar del Río. Se emplearon métodos teóricos como el análisis documental; empíricos, la observación, entrevista semi-estructurada y encuesta; y de medición, palpación, test de Neer, ultrasonido, test de fuerza en Y, test de resistencia específica y escala visual analógica para el dolor. Los resultados obtenidos durante el proceso de diagnóstico revelaron que el 80 % de los atletas presentó dolor en la articulación glenohumeral durante el examen físico y las pruebas de diagnóstico diferencial confirmaron alteraciones como tendinitis y miositis en el 80 % de la muestra; se comprobó que el plan de prevención institucional fue descriptivo y no abordó la identificación sistemática de factores de riesgo, con una aplicación insuficiente de



métodos de recuperación activa como la crioterapia y el masaje deportivo; se constató una alta prevalencia de síntomas lesionales y deficiencias significativas en el proceso de prevención, lo que evidenció la necesidad de desarrollar e implementar una metodología, con la integración del screening periódico, el fortalecimiento específico y estrategias de recuperación avanzadas para mitigar el riesgo de lesiones por sobreuso.

Palabras clave: deportistas de alto rendimiento, diagnóstico, manguito rotador, natación, prevención de lesiones

RESUMO

Este artigo teve como objetivo caracterizar o estado atual do processo de prevenção de lesões por sobrecarga do manguito rotador em uma amostra de jovens nadadores de alto rendimento, como fase inicial para o desenvolvimento de uma metodologia específica. Um estudo descritivo com abordagem mista foi conduzido em uma amostra intencional de atletas e treinadores da Academia Provincial de Natação "Pedro Téllez Valdés" em Pinar del Río. Os métodos teóricos incluíram análise documental; os métodos empíricos incluíram observação, entrevistas semiestruturadas e questionários; e os métodos de mensuração incluíram palpação, teste de Neer, ultrassonografia, teste de força em Y, teste de resistência específica e escala visual analógica para dor. Os resultados obtidos durante o processo diagnóstico revelaram que 80% dos atletas apresentavam dor na articulação glenoumeral durante o exame físico, e os testes de diagnóstico diferencial confirmaram alterações como tendinite e miosite em 80% da amostra. Constatou-se que o plano institucional de prevenção era descritivo e não abordava a identificação sistemática de fatores de risco, com aplicação insuficiente de métodos de recuperação ativa, como crioterapia e massagem esportiva. Observou-se uma alta prevalência de sintomas de lesão e deficiências significativas no processo de prevenção, o que destaca a necessidade de desenvolver e implementar uma metodologia que integre avaliações periódicas, exercícios específicos de fortalecimento e estratégias avançadas de recuperação para mitigar o risco de lesões por sobrecarga.

Palavras-chave: atletas de alto rendimento, diagnóstico, manguito rotador, natação, prevenção de lesões



INTRODUCTION

Since its founding, the Institute of Sports Medicine in Cuba has aimed to study the psychomorphofunctional aspects of the athlete, in order to understand how to cope with physical exertion and improve biological organization without affecting the balance of the internal-organic environment, due to the influence of the external environment - sports training.

Consequently, somatic recovery is included from a multidisciplinary work system with the application of prophylactic plans, to assist the athletes who assume responsibility for their health and contributes to the rest of the medical specialties, integrated into the technical groups of coaches.

In this context, high-performance swimming is characterized by extremely high training volumes and intensities. Swimmers perform thousands of repetitions of the technical movements per week, subjecting the shoulder joint to significant and recurrent mechanical stress. As a result, rotator cuff overuse injuries are the most prevalent musculoskeletal pathology in this population and represent a health problem that can limit performance, interrupt an athlete's career, and affect their quality of life.

Swimming is one of the most practiced individual sports worldwide, due to the real benefits it has on the systematic health of the population and because it allows one to experience skills in an environment completely different from the one in which one lives (Brum and Santos, 2020).

Swimming has historically been among the most iconic and popular sports of the Olympic Games, present in every edition since its revival in 1896. Along with athletics, cycling, fencing, and gymnastics, it forms part of the select group of disciplines that have witnessed the evolution of the Olympics throughout history. In each competition, the Olympic pool becomes a stage for records, thrilling rivalries, and unforgettable moments.

Competitive swimming has a program of 37 events that encompass a wide variety of speed and resistance tests where the events are distributed in pursuit of gender equality and offer



a virtually symmetrical program for men and women, in addition to including mixed events that encourage collaboration and diversity in the sport.

The competitive swimming program features 17 events for men and 17 for women. In addition, there is a mixed event, the 4x100 meter medley relay, which adds a touch of innovation and dynamism to the program. These 35 pool events are complemented by two 10-kilometer open water marathons, one for men and one for women, bringing the total to 37 Olympic swimming events.

The pool events consist of speed and resistance events, covering all swimming strokes and a wide range of distances, from the explosive 50 meters to the stamina of the 1500 meters. The complete list of events, separated by stroke and distance, is as follows:

Freestyle (crawl): This is the fastest and most popular swimming style. In the Olympic Games, the program includes the 50m, 100m, 200m, 400m, 800m, and 1500m races for both men and women.

Backstroke: This stroke is characterized by swimming on the back, with coordinated arm and leg movements. The races are the 100 and 200 meters for men and women.

Breaststroke: This is a slower stroke, but it requires great coordination and strength. Men and women compete in the 100 and 200 meters.

Butterfly stroke: It is considered one of the most physically demanding, requiring great power and technique, with Olympic events of 100 and 200 meters for men and women.

Individual medley: This event tests the versatility of swimmers who must complete the race using all four strokes in a specific order: butterfly, backstroke, breaststroke, and freestyle. It is contested in the 200 and 400 meters for both men and women.

Relays: Relay events encourage teamwork and strategy, where teams of four swimmers combine to complete the distance. The relay program includes the men's and women's 4 x 100m freestyle, the men's and women's 4 x 200m freestyle, and the men's, women's, and mixed 4 x 100m medley.



Open water swimming: competitions are held in open water (lake or sea), with 5 km, 10 km, and 25 km races for men and women. However, only the 10 km event is included in the Olympic program for both men and women. Open water competitions are usually separate from other swimming competitions, with the exception of World Swimming Camps and the Olympic Games.

Since its inception, the International Swimming Federation (FINA, 2015) has addressed the issue of injuries in competitive swimming and defines them as the most characteristic potential injuries of swimmers:

- Epicondylitis in the butterfly elbow.
- Lumbar pathology (spondylosis) in butterfly and breaststroke.
- Shoulder subluxation in the back.
- Patellofemoral (knee) pain in the breaststroke.
- Tenosynovitis of the foot extensors, in crawl and backstroke.
- Painful shoulder syndrome in crawl and butterfly.

Pink and Tibone (2000, cited by Sein et al., 2010) state that of the types of injuries in swimming, the most frequent are those called painful shoulder syndrome, which is also known as swimmer's shoulder, and within this term are included a series of injuries such as acromioclavicular arthritis, multidirectional glenohumeral instability and rotator cuff compression pathology, which is the most frequent and important.

According to Oliveira et al. (2020), the shoulder is a joint that forms part of the upper body and is made up of bones, ligaments, tendons, and muscles that connect the arm to the torso. The main bones involved are the clavicle, scapula, and humerus.

Thus, three joints can be found within the shoulder: the acromioclavicular joint, formed by the clavicle and the acromion, which allows the arm to be raised above the head; the glenohumeral joint, formed by the humerus and the glenoid fossa of the scapula, which allows the arm to rotate; and the sternoclavicular joint, which connects the upper limb to the axial skeleton and allows flexion and abduction.



Prevention is essential for athletes to achieve longevity and, consequently, improve their competitive performance throughout their careers. The aim of prevention is to reduce the occurrence of sports-related injuries; its function is to eliminate risk factors and it depends on several components such as physical and psychological preparation, adherence to the rules and regulations of each sport, health checkups, nutrition and hydration, and recovery of body parts overloaded by physical exertion.

These elements are explicitly endorsed by Martínez (2006), who argues for the need to prevent injuries in order to minimize the risk factors to which athletes are exposed during training and competition. According to Gabbett (2020), from a physical performance perspective, injury prevention in sports requires, first, identifying and then classifying intrinsic and extrinsic risk factors, and emphasizing modifiable ones because these allow for measurable and quantifiable changes to achieve overall and effective improvement, rather than relying on isolated preventative measures.

Despite the high incidence of these injuries, previous research (Jobe & Pink, 1993; McMaster et al., 1995; Wanivenhaus et al., 2012) has addressed prevention in isolation, emphasizing muscle strengthening and technical correction, but without fully integrating recovery processes as a central component of prevention. Contemporary authors such as Kibler et al. (2013) and Cools et al. (2014) propose a proactive approach that combines periodic screening with eccentric and scapular strengthening.

However, in the Cuban context there persists a lack of correspondence between the preventive objectives set out in the normative documents (Swimming Athlete Preparation Program and Prophylactic Plan) and the procedures used in daily practice, which tend to be general, descriptive and focused on passive recovery.

Therefore, this article aims to characterize the current state of rotator cuff overuse injury prevention in a sample of high-performance youth swimmers. This assessment is essential for establishing and subsequently designing a specific methodology to optimize prevention through training.



MATERIALS AND METHODS

The research was descriptive, quantitative, and purposive, conducted at the "Pedro Téllez Valdés" Provincial Swimming Academy in Pinar del Río, Cuba, between September 2023 and March 2024. A purposive non-probability sampling method was used, selecting a sample of 10 athletes in the 15-17 age category (41% of the total population of 27 athletes), with an average age of 16.1 years and more than 10 years of swimming experience. All athletes had experience in national competitions. In addition, 10 coaches with experience in the sport were included.

1. A triangulation of empirical methods was used for the diagnosis:
2. Document analysis: the athlete preparation programs for swimming (2023-2025), the physioprophylactic process plan, medical histories and charge sheets from the sports medicine department were reviewed.
3. Observation: nine open observations were made to training sessions (three in the general stage, three in the special stage and three in the competitive stage), using an observation guide with indicators such as compliance with the preventive plan, warm-up, load control, technical execution, work-rest relationship and recovery methods (cryotherapy, massage).
4. Semi-structured interview: applied to 13 members of the multidisciplinary group (six coaches, three physiotherapists, one sports doctor, one imaging technician, one psychiatrist, one manager and the 10 coaches).
5. Specific measurements: tests were applied to evaluate the three dimensions of the dependent variable:
 - Physical Examination: palpation, y-strength test, specific resistance test.
 - Differential Diagnosis: Neer test, ultrasound.
 - Recovery Strategies: Visual Analogue Scale (VAS), for the level of post-exertion muscle recovery, recording of the use of cryotherapy and sports massage.

Data Analysis: The information obtained was processed using content analysis and descriptive statistics; the results were presented in frequency tables.



RESULTS

The analysis of the Swimming Athlete Preparation Program revealed insufficient general information regarding injury prevention. It was found that the Sports Medicine Center's prevention plan is descriptive, defining the problem in terms of incidence and prevalence, and lacked a standardized methodology and analytical studies to identify individual risk factors. As observed, emphasis was placed on therapeutic massage at the expense of recovery massage, demonstrating a lack of updating and alignment with the contemporary needs of high-performance sports.

The interviews revealed that 71% of coaches felt the prophylactic plan was ineffective, and 100% acknowledged the need for a specific preventative program for swimming, although they noted its difficult implementation. The professionals agreed that the plan had not undergone significant changes since its inception in 1966 and lacked a methodology for identifying risk factors in each athlete.

As a result of the nine observations made to the training sessions in the different stages of the preparation planning process (three in each of the stages: general, special and competitive), according to the information collected (table 1), it was shown that although the preventive plan was fulfilled in most of the sessions, its application was insufficient.

Recovery was predominantly applied at the end of training and was passive (slow movements in the water). Cryotherapy was only observed in three athletes on two occasions, and sports massage in only one athlete on one occasion. Furthermore, it was considered that certain risk factors that could have led to injuries should have been taken into account.

An analysis based on the specific characteristics of swimming revealed that aspects related to planning and the correlation between training content, monitoring the planned workload, and evaluating the warm-up in each session were generally performed well. However, the first two observations showed some deficiencies in these areas.



In an aspect as important as the correct execution of the technique in the exercises to be trained, most of the athletes showed mastery in the execution, especially in those observations that coincided with the special and competitive stages.

In other aspects related to recovery and the work-rest ratio, coaches generally demonstrated control over the intensity of the exercises, although in almost all the training sessions evaluated, this targeted intervention occurred at the end of the training session. It was considered advisable to monitor recovery throughout all phases of the training session.

When considering the forms and methods of applying recovery during training sessions, it was found that on 75% of occasions they ended with slow and passive movements within the pool, and the time was used to evaluate and guide the next objectives in the upcoming sessions.

When considering the risk factors for injuries, based on the particularities of swimming, on only one occasion were three athletes observed applying ice (cryotherapy) and at no time did they use sports massage as a recovery method, which, due to all the proven benefits, could accelerate the recovery from the loads received by the swimmers and prepare them to be in better shape for the next training loads. (Fig 1)

Indicadores Observados	Etapa General			Etapa Especial			Etapa Competitiva		
	No se cumple	Se cumple	Se cumple	Se cumple	Se cumple	Se cumple	Se cumple	No se cumple	No se cumple
1	No se cumple	Se cumple	Se cumple	Se cumple	Se cumple	Se cumple	Se cumple	No se cumple	No se cumple
2	No Adecuado	Adecuado	Adecuado	Adecuado	Adecuado	Adecuado	Adecuado	Adecuado	Adecuado
3	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí	Sí
4	No	No	Sí	Sí	Sí	Sí	Sí	Sí	Sí
5	No	Sí	No	Sí	Sí	Sí	No	Sí	Sí
6	Con errores	Con errores	Correcta	Correcta	Correcta	Correcta	Correcta	Correcta	Correcta
7	No controlado	No controlado	Controlado	Controlado	Controlado	Controlado	Controlado	Controlado	Controlado
8	Final	Final	Final	Final	Principal-Final	Final	Final	Principal-Final	Final
9	No se hace	No se hace	No se hace	3 atletas	5 atletas	No se hace	No se hace	No se hace	3 atletas
10	No se hace	No se hace	No se hace	No se hace	No se hace	No se hace	No se hace	No se hace	Un Atleta

Indicators observed: 1: Compliance with the Preventive Plan; 2: Warm-up; 3: Alignment between planned and actual results; 4: Training Load Control; 5: Correlation between contents; 6: Technical execution; 7: Work-Rest relationship; 8: Training recovery; 9: Recovery (Cryotherapy); 10: Recovery (Massage).

Figure 1. Results of the observation of training sessions



In turn, in Table 1, an assessment of overuse shoulder injuries of the rotator cuff was observed, based on the different tests applied, from the three dimensions, to the 10 swimming athletes of the Pinar del Río youth team, during the diagnosis carried out.

Table 1. Results of the assessment of rotator cuff overuse shoulder injuries during diagnosis.

Physical Examination Dimension											
Results of the First Sample	Palpation		Y-axis Strength Test			Specific Resistance Test					
	No pain	There is pain.	No pain	Mild pain	Intense pain	No pain	Mild pain	Intense pain			
Equipment	2	8	2	5	3	1	5	4			
Differential Diagnosis Dimension											
First Results Sample	Test Neer			Ultrasound							
	No pain		There is pain.	Negative	Tendinitis	Bursitis	Rupture Partial	Myositis			
Equipment	3		7	3	4	-	-	3			
Recovery Strategy Dimension											
First Results Sample	Post-exertion muscle recovery level (EVA)					Cryotherapy			Sports Massage		
	No pain	Light	Moderate	Intense	VeryIntense	Yeah	No	Sometimes	Yeah	No	Sometimes
Equipment	2	4	4	-	-	-	9	1	-	10	-

Source: Own elaboration

In dimension I, corresponding to the physical examination, 80% of the athletes reported feeling sensations of pain in the scapulohumeral joint, which indicated the existence of limitations in the exercise in training and effects on sports preparation.



In dimension II, concerning differential diagnosis, where the Neer test and ultrasound were used, it was found that seven of the athletes (70%) reported shoulder joint pain, consistent with possible tendon inflammation (tendinitis). This was confirmed by the ultrasound images, which showed that seven athletes presented with tendinitis (4) and myositis (3), thus corroborating the symptoms observed during the physical examination.

Regarding the recovery strategy, based on the prevention control, and assessed by the post-exertion muscle recovery level test (EVA), eight of the athletes (80%) reported a sensation of pain, of which four mentioned light pain and four moderate pain, after the activity.

In the tests of recovery control after exertion, when assessing the application or not of the use of cryotherapy and sports massage methods, it was found that only one athlete (10%) used the cryotherapy method sometimes for recovery and none of the team members received the application of sports massage as a means of recovery and prevention of injuries, even when assessing the particularities of this sport due to the risk of shoulder injuries from overuse of the rotator cuff, based on the number of movements performed during the entire training process.

In summary, the diagnosis referred to the need for assessment of training demands, the influence of injury risk factors to which the athletes were exposed and the particularities of swimming, and for a methodology for injury prevention that contributes to optimizing the performance and results of the swimmers.

DISCUSSION

The results of this diagnosis revealed a worrying reality: the high prevalence of signs and symptoms of rotator cuff injury in young, high-performance swimmers, coexisting with an institutionally deficient prevention system. The finding that 80% of the athletes presented with pain and clinical alterations (tendinitis/ myositis) was consistent with the literature describing swimming as a high-risk activity for the shoulder due to repetitive microtrauma, according to Brukner and Khan (2017). However, the novelty of this study lay in the observation that these injuries were not merely the result of the sport's load, but were mediated by an inadequate prevention process.



The deficiencies identified in regulatory documents and daily practice, such as the lack of a structured methodology and the emphasis on passive and insufficient recovery methods, contradicted the proactive and multifactorial approaches recommended by current literature. While agreeing with Cools et al. (2014) and Tate et al. (2015) that prevention should include periodic screening, specific strengthening, and continuous technical correction, these results also indicate that these actions are unfeasible without a system that actively integrates and monitors the athlete's recovery, not only at the end but throughout the entire training process.

Rehabilitation treatment, as the first line of conservative intervention, was based on exercise programs to improve stability, mobility, and prevention. The studies analyzed demonstrated that exercise programs (especially in water) were predominant and effective in reducing symptoms. For example, studies such as those by Takayama et al. (2024) and Raffini et al. (2024) highlighted the superiority of aquatic exercises (front crawling, wooden training) over land-based exercises in pain management.

Additionally, techniques such as neuromuscular taping (Abshenas et al., 2021) showed a significant reduction in symptoms by improving blood flow and decreasing peripheral inflammation (Dehghan et al., 2023). It was noted that these results were not effective without the integration of a system to monitor the prevention process in athletes throughout their training.

In the case of subacromial impingement syndrome, one of the most frequent causes of glenohumeral pain was protocols that combined rhythmic stabilization exercises, stretching, and positional release therapy. Chaloub et al. (2024) reported greater efficacy when integrating ultrasound with exercises, while Karthikeyan et al. (2024) and Almasoudi et al. (2023) emphasized dynamic muscle strengthening to avoid invasive interventions.

These results support the literature that proposes rehabilitation as an alternative to corticosteroids or surgery (Meneses, 2018). One of the most determining factors in this process is related to the physiological recovery of the athlete's body; hence, the importance of prioritizing the control of risk factors in the prevention plan, according to Zabludovsky



(1906), where one of the ways to accelerate the recovery process is through the application of sports massage techniques.

For scapular dyskinesia, defined as a biomechanical alteration characterized by atypical scapular movements, studies such as Jildeh et al. (2021); Srinivasan et al. (2024) apply scapular stabilization and strengthening exercises and achieve improvements comparable to those reported in interventions based on stretching and postural re-education (Cools et al., 2014; Nowotny et al., 2016).

While rehabilitation treatments demonstrate clinical effectiveness, their implementation requires professionals trained in diagnostic assessment, therapeutic planning, and adaptive monitoring (López et al., 2017). The main limitations lie in non-randomized methodological designs and small sample sizes, which underscores the need for future studies with representative samples and control groups to strengthen the evidence.

The near-total absence of cryotherapy and sports massage was a critical finding. When properly applied, these methods are powerful tools for accelerating recovery, reducing inflammation, and preventing the chronicity of micro-tears. Their unsystematic application revealed a gap between available scientific knowledge and sports practice in the analyzed context. The fact that recovery was limited to passive cooling in water underestimated the regenerative potential of these techniques.

Therefore, this diagnosis not only confirmed the identified health problem but also laid the empirical groundwork for designing a comprehensive prevention methodology. This methodology encompasses physical examination, differential diagnosis, and recovery strategies as a system; it is systematic, with periodic screening and standardized protocols; and it is proactive, anticipating risk factors through eccentric strengthening, technical correction, and the planned application of advanced rehabilitation methods. Future research should validate the effectiveness of a methodology designed under these principles.

CONCLUSIONS

The diagnosis revealed a high prevalence of symptoms and signs of rotator cuff overuse injury in the youth swimmers of the sample, associated with an institutional and practical



prevention process that presented significant deficiencies that included descriptive prevention plans without a methodological focus, absence of systematic identification of risk factors, and an underutilization of active recovery methods such as cryotherapy and sports massage.

The need to move beyond the current approach to implement a comprehensive and proactive prevention methodology was confirmed, integrating periodic screening, specific strengthening, and advanced recovery strategies within the training process, with the aim of reducing the incidence of injuries, optimizing performance, and prolonging the sporting life of high-performance swimmers.

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Conflict of interest statement:

The author declares that there are no conflicts of interest.

Author's contribution:

The author is responsible for writing the work and analyzing the documents.



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