Mechanical hyperalgesia in athletes' shoulder: integrative review

Hiperalgesia mecânica no ombro de atletas: revisão integrativa

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ABSTRACT

BACKGROUND AND OBJECTIVES: Chronic shoulder pain in throwing athletes is a common complaint in everyday practice. Despite the growing number of publications, it is unclear whether these athletes have mechanical hyperalgesia associated with pain, which could alter the treatment options undertaken. The aim of the study was to summarize the results of the main evidence found on the pressure pain threshold in the shoulder, to compare these results in athletes of different sports.

METHODS: Electronic search via PubMed/Medline, PEDro, SPORTDiscuss, Web of Science and Scielo databases was done verifying studies in English or Portuguese. The keywords: pressure pain threshold; athletes; shoulder; pressure algometry and its derivations were searched in both languages. The articles should have included athletes from sports that use upper limbs and that assess the pressure pain threshold in the shoulder. Five studies were included for analysis.

RESULTS: Athletes with shoulder pain had a lower pressure pain threshold. In swimmers, changes in mechanical sensitivity to pain seem to be related to weekly training hours, years of sports practice and age group. Sports competitions apparently have an influence on the reduction of pressure pain threshold in amateur tennis players.

CONCLUSION: Swimming athletes have a lower pressure pain threshold and this is related to the volume and time of training in the modality. This variable seems to be sport-dependent, and the absence of a greater number of studies in sports such as tennis and wheelchair basketball limits conclusions on this subject.

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HIGHLIGHTS

- Shoulder pain is a common condition in overhead athletes, and athletes with shoulder pain have changes in pressure pain threshold (PPT).
- In swimming, PPT seems to be influenced by weekly training volume, years of practice, and age group.
- PPT changes in wheelchair tennis and basketball players still lack more conclusive data.

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Keywords: Athletes, Hyperalgesia, Shoulder, Trigger points.

RESUMO

JUSTIFICATIVA E OBJETIVOS: A dor crônica no ombro de atletas arremessadores é uma queixa comum no cotidiano do esporte. Apesar do número crescente de publicações sobre o tema, não está claro se esses atletas apresentam hiperalgesia mecânica associada a dor, o que poderia alterar as abordagens de tratamento realizadas. O objetivo da presente pesquisa foi sintetizar os resultados das principais evidências encontradas sobre o limiar de dor a pressão no ombro, comparando estes resultados em esportistas de diversas modalidades.

MÉTODOS: Para esta revisão integrativa, as buscas eletrônicas ocorreram nas bases de dados Pubmed/Medline, PEDro, SPORTDiscuss, *Web of Science* e Scielo, verificando estudos em inglês ou português. As palavras-chave *pressure pain threshold; athletes; shoulder; pressure algometry* e suas derivações foram pesquisadas em ambas as línguas. Os artigos deveriam incluir atletas de esportes com gestos esportivos no membro superior e que avaliassem o limiar de dor a pressão no ombro. Cinco estudos foram incluídos para análise.

RESULTADOS: Atletas com dor no ombro apresentaram menor limiar de dor a pressão. Em nadadores, as alterações na sensibilidade mecânica a dor parecem estar relacionadas com horas de treino semanais, anos de prática esportiva e faixa etária. As competições esportivas aparentemente possuem influência na redução do limiar de dor a pressão em tenistas amadores.

CONCLUSÃO: Atletas de natação apresentam menor limiar de dor a pressão, o qual se relaciona com o volume e tempo de treinamento na modalidade. Essa variável parece ser esporte-dependente, e a ausência de um maior número de estudos em esportes como tênis e basquete em cadeiras de rodas limita conclusões acerca do assunto.

Descritores: Atletas, Hiperalgesia, Ombro, Pontos-gatilho.

INTRODUCTION

Chronic pain (CP) of the shoulder is a condition commonly reported by athletes who practice overhead sports[1-8]. In adolescent judo, handball, and basketball athletes, there is a 63.8% prevalence of shoulder overload injuries[9], and a high rate is also present in athletes with more than 5 years of sports practice at university level[8]. In professional athletes, shoulder CP represents approximately 19% of the injuries in volleyball[10] and between 52% and 58% of complaints at some point of the season in handball[11,12].

The pain is considered chronic when persistent for a period longer than three months[13], being defined as primary when not explained by the presence of another clinical condition, or chronic disease, relating to emotional suffering or functional disability[13,14]. On the other hand, secondary chronic pain is usually related to another pathological event, being initially a symptom, but persistent even after the successful treatment of the underlying disease[13].

Alterations in neural sensitization are described in pain pictures and are generally natural responses to an injury[15]. Peripheral sensitization can be defined as an increase in the peripheral nociceptive response due to a stimulus in its receptive fields, presenting, in sensitized nerves, altered action potentials, but normal nerve conduction[16]. Central sensitization (CS) is represented by an increase in the central nervous system neuronal response due to a painful afferent stimulus[16] or stimuli that are generally non-painful, inducing exacerbated and diffuse pain responses[17].

The evaluation of the pressure pain threshold (PPT) is one of the ways to estimate the mechanical sensitivity to pain, which corresponds to the moment when the pressure exerted on a tissue becomes a painful stimulus[18,19]. In cases of unilateral shoulder pain, a low PPT in the affected limb compared to the unaffected one indicates the presence of peripheral sensitization[15]. In contrast, low PPT in tissues remote to the affected site (tibialis anterior, contralateral upper limb) suggests the presence of central sensitization[15], one of the mechanisms suggested for the development of CP[15,20].

According to a systematic review with meta-analysis that evaluated studies involving individuals with CP of several etiologies, the PPT in these populations was lower compared to asymptomatic control groups, showing generalized mechanical hyperalgesia in CP subjects[21]. Therefore, reviews on the presence of PPT in patients with shoulder CP are already available[22,23], showing that individuals with tendinopathy or overload lesion in the upper limbs presented bilateral hypersensitivity during PPT measurement, when compared to asymptomatic individuals, but this finding showed low to moderate quality of evidence[23]. Furthermore, patients with shoulder pain did not present changes in the PPT, only changes in the supra-threshold of pain to heat (hypersensitivity) when compared to asymptomatic patients[22].

However, PPT is still a variable that should be further explored in athletes, because with the growing number of publications on the subject there is a need to organize the results of the main evidence found.

The purpose of this study was to synthesize the main results of existing research about PPT in the shoulder of athletes and to compare the results of PPT in athletes from different sports.

METHODS

An integrative review was carried out with the objective of identifying the existing works in the national and international literature on the theme "shoulder PPT in athletes". Without filters to determine the period, Pubmed, PEDro, Scielo, SPORTDiscus and Web of Science databases were searched. The MeSH terms and keywords combinations were used: pressure pain threshold AND athletes; pressure pain threshold AND shoulder; pressure algometry AND shoulder; pressure algometry AND athletes. In the Scielo database searches, the following combinations of keywords in Portuguese were also used: *limiar de dor a pressão* AND *atletas; limiar de dor a pressão* AND *ombro; algometria por pressão* AND *ombro; e algometria por pressão* AND *atletas.*

This study included scientific articles published in English or Portuguese that evaluated PPT in the shoulder region and that involved athletes from all competitive levels, from sports that predominantly use the upper limbs in the sportive gesture and, therefore, had high prevalence of shoulder injuries, such as swimming[24], volleyball[25], rugby[26], handball[27], tennis[28,29] and baseball[30]. Studies that evaluated PPT in other body segments in athletes or shoulder PPT in non-athletes, or that used other forms of pain assessment in athletes other than PPT were excluded. PPT measurements at points distal to the shoulder, to assess the presence or absence of pain in athletes were not considered an exclusion factor.

The search for the studies occurred in the following order: search of the databases using MeSH terms and keywords, reading of the titles, selection and reading of the abstracts of the pre-selected studies. Then, the papers that fit the inclusion criteria were selected for full reading. The extraction of data from the full reading was performed to fill a table with the eligibility criteria; after the final selection of studies, an integrative review was performed with critical analysis of the results.

RESULTS

Initially, 1,374 studies were found, and 19 duplicate studies were manually excluded, resulting in 1,355 studies. Of these, 1,341 were excluded in the reading of titles and abstracts. This left 14 studies for full-text review. Of these, a total of nine were excluded for evaluating PPT in other body segments of athletes or for evaluating thermal sensitivity in athletes rather than mechanical pain sensitivity. At the end of this review, five studies that met the eligibility criteria were included (Figure 1).

Three of the included studies were present in Pubmed, SPORTDiscus, and Web of Science databases, one was present in both Pubmed and Web of Science, and one was present in Web of Science alone.

The publications date from the period of 2011 to 2020, with studies from Spain, Belgium, Brazil, and Turkey. Swimming[31-33], wheelchair basketball[34] and tennis[35] athletes were evaluated. Regarding the competitive level, two studies evaluated elite athletes[33,34], one evaluated competitive sportsmen[31], one evaluated competitive and amateur sportsmen[32], and another study evaluated amateur university athletes[35] (Table 1).

The competitive level of the participants was defined differently in each publication. For swimmers, those who trained at least 4 hours a week and participated in competitions at regional, national, and/or international level[31] - as well as those who trained at least 3 times a week, swam at least 4000 meters a day, and participated in some professional competition for at least

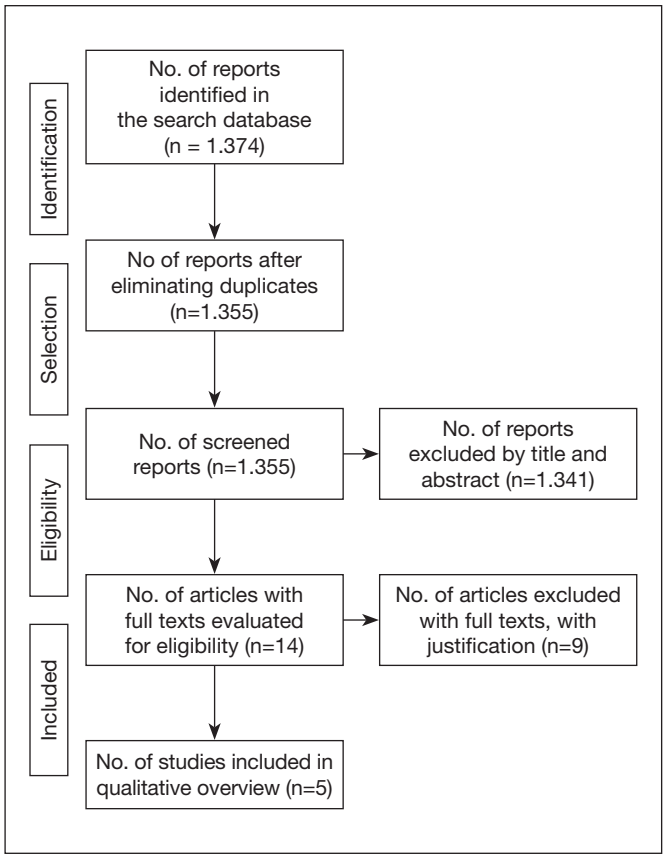

Figure 1. Stages of the study development and article selection

a year[32] - were considered competitive. One of the studies classified elite swimmers as those who had trained for at least 2.5 years under the supervision of a coach and who swam more than 6 hours a week[33]. In addition, swimmers who practiced the sport at most 2 times a week were considered amateurs[32].

For wheelchair basketball athletes, the classification as an elite athlete was determined by the functional classification of the International Wheelchair Basketball Federation, based on the functional, motor and cognitive performance of the athletes[34].

In the study that evaluated tennis players, the characteristics that determined the competitive level were not described; it was only reported that all of them played the sport as amateurs at the college level[35].

Table 2 presents the characterization of the included studies and their main outcomes. The presence of active trigger points was a common finding in athletes with shoulder pain[33,34].

Regarding the PPT, only one study in swimmers reported threshold reduction, with the presence of central and peripheral sensitization in this population with and without shoulder pain[33], defined by the presence of low PPT values in the anterior tibial muscle or in tissues remote to the painful limb[33,34]. Wheelchair basketball players with shoulder pain showed reduced PPT and presence of central and peripheral sensitization compared to asymptomatic athletes of the same sport and traditional basketball[34].

PPT was also evaluated over four consecutive days of amateur tennis competition[35] and there was a PPT reduction throughout the competition.

Table 1. Characteristics of the studies included in this review

Authors	Sport	Methodology	Competitive level	Participants	Average training time (years)	Average training time (hours/week)
Kuppens et al.[31]	Swimming	Observational study	Competitive	Mean age of 15.5±2.7 years 102 healthy swimmers (54 males and 48 females) Age range between 10 and 25 years	Data not provided by the study	11.6±4.6 weekly training hours
Hidalgo-Lozano et al.[33]	Swimming	Observational study	Elite	Age range between 18 and 28 years 17 swimmers with pain - mean age 21±3 years (9 men and 8 women) 18 without shoulder pain - mean age 20±3 years (9 males and 9 females) 15 healthy athletes - mean age 23±4 years (7 men and 8 women) from other sports (athletics and skiing) as control group	Swimmers with shoulder pain: 11.6±3.4 years of training in the sport Swimmers without shoulder pain: 8.9±2.7 years of training in the sport Control group: 11.1±5.5 years of training	Swimmers with shoulder pain: 26.8±4.8 training hours per week Swimmers without shoulder pain: 26.1±5.5 hours training per week Control group: 23.4±4.2 weekly hours of training
Habechian et al.[32]	Swimming	Observational study	Competitive and amateur	Age range between 8 and 15 years 30 not practicing sports - mean age 11.50±1.94 years (14 girls and 16 boys) 30 amateur swimmers - mean age 11.56±1.81 years (18 girls and 12 boys) 30 competitive swimmers - mean age 12.63±2.02 (17 girls and 13 boys)	Amateur swimmers: 4.36±2.91 years of training in the sport Competitive swimmers: 7.60±2.61 years of training in the sport	Data not provided by the study

Continue...

Table 1. Characteristics of the studies included in this review – continuation

Authors	Sport	Methodology	Competitive level	Participants	Average training time (years)	Average training time (hours/week)
Ortega-Santiago et al.[34]	Wheel-chair Basketball	Observational study	Elite	Age range 18-50 years 18 wheelchair basketball players with shoulder pain - mean age 30±8 years 22 wheelchair basketball players without shoulder pain - mean age 32±10 years 20 traditional basketball players - mean age 31±7 years	Data not provided by the study	Data not provided by the study
Kafkas et al.[35]	Tennis	Experimental study	Amateur college students	Age range 19-30 years 58 tennis players: 25 females - mean age 24.35±5.42 years 34 men - average age 25.10±6.05 years	Data not provided by the study	Data not provided by the study

Table 2. Goals, methods, results and conclusion of the included articles.

Authors	Goals	Methods	Results	Conclusion
Kuppens et al.[31]	To evaluate the relationship between pain threshold and training volume in competitive swimmers, using static (pressure pain threshold - PPT) and dynamic (conditioned pain modulation) measurement tools.	Digital Algometer (Wagner Instruments, Greenwich, CT, USA). PPT measurement sites: upper trapezius, dorsal side of the middle phalanx of the third finger, proximal third of the calf muscle.	Average swimming training: 11.6 h/week. PPT associated with conditioned pain modulation: external painful stimulus applied to the upper portion of the non-dominant upper limb during PPT reassessment was superior to isolated PPT measurement; Swimmers exposed to a higher volume of training showed higher PPT, indicating less sensitization to pain in these athletes; Swimmers with lower training volume obtained lower PPT; There was no correlation between training volume and conditioned pain modulation as a measure of endogenous pain modulation capacity.	Pain perception may be influenced by the volume of swim training; Swimmers who had a greater number of hours of training obtained higher PPT in various parts of the body, indicating less sensitization to pain and possible training-induced hypoalgesia; No associations were found between training load and measures of endogenous pain inhibition.
Hidalgo-Lozano et al. [33]	To evaluate and compare PPT, presence of active and latent trigger points in elite swimmers with and without shoulder pain and in healthy elite athletes.	Mechanical pressure algometer (Pain Diagnosis and Treatment Inc., Great Neck, NY, USA). PPT measurement sites: Elevator of the scapula Sternocleidomastoid Upper trapezius Scalene Infra-spinal Subscapular Tibialis anterior	Swimmers in pain: 65% had pain during training; PPT lower than the control group; Fewer active trigger points. Swimmers without pain: Lower PPT than the control group in the upper trapezius, subscapular, and anterior tibial muscles; Higher number of latent trigger points. No significant difference in PPT and trigger points between the groups with and without pain; Higher number of trigger points in the groups with and without pain than in the control group (healthy athletes from other sports).	Elite swimmers with and without shoulder pain showed lower PPT values compared to the group of healthy athletes; Low PPT values were also found in the tibialis anterior in swimmers with and without shoulder pain, suggesting the presence of CS in these athletes; Elite swimmers with and without pain showed peripheral and central sensitization; Findings of active trigger points in the shoulder/neck directly contributed to pain complaint in elite swimmers; Similar PPT were found between the two groups of swimmers, suggesting that elite swimmers may be predisposed to develop a degree of mechanical sensitization related to the specific physical demands of swimming.

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Table 2. Goals, methods, results and conclusion of the included articles – continuation

Authors	Goals	Methods	Results	Conclusion
Habechian et al.[32]	To compare scapular kinematics, scapulo-thoracic muscle activation, and PPT at the shoulder in young non-sport players, amateur swimmers, and competitive swimmers.	Digital Algometer (model OE-220; ITO Physiotherapy & Rehabilitation, Saitama, Japan). PPT measurement sites: • Superior trapezius • Infra-spinal • Supraespinal • Middle deltoid • Tibialis anterior	Competitive swimmers presented: Greater internal rotation of the scapula - at 90° and 120° of shoulder elevation - and anterior tilt of the scapula - at 90° of shoulder elevation - compared to non-athletes; Greater activation of the serratus anterior between 60° and 120° of shoulder elevation compared to amateur swimmers, and from 90° to 120° compared to non-competitive individuals; Greater anterior scapular tilt of amateur swimmers between 90° and 120° of shoulder elevation compared to non-swimmers; No difference in upper and lower trapezius muscle activation between groups; No difference in PPT between groups in all muscles evaluated; There was no correlation between scapular kinematics and PPT.	Young competitive swimmers showed changes in scapular kinematics and scapulothoracic muscle activation during shoulder elevation that may be related to the sport practice; Mechanical pain sensitivity (PPT) was not altered in the evaluated young swimmers.
Ortega-Santiago et al. [34]	To investigate the presence of PPT and trigger points in the shoulder/neck muscles in elite male wheelchair basketball athletes.	Mechanical pressure algometer. Measurement sites of the PPT: Between the zygapophyseal joint between C5 and C6 Deltoid Second metacarpal	Wheelchair Basketball Group with shoulder pain: Mean duration of shoulder pain of two years; Lower bilateral PPT at the shoulder, at the zygapophyseal joint between C5 and C6 and at the second metacarpal compared to the other groups; Higher number of active trigger points compared to the other groups. Wheelchair Basketball Group without shoulder pain: Difference in the number of trigger points in the upper trapezius compared to the group with pain, showing higher number of latent trigger points in this muscle. All groups present a similar number of latent trigger points.	Hypersensitivity and a significant number of active trigger points in elite wheelchair basketball athletes with shoulder pain compared to asymptomatic players of the same sport and traditional basketball; No differences were found between wheelchair basketball athletes without shoulder pain and traditional basketball athletes.
Kafkaset et al.[35]	To evaluate changes in palm grip strength and PPT during amateur tennis competition.	Digital algometer (Chatillon DFE-100, Digital Force Gauge/ AMETEK). Sites for measuring the PPT: Lateral epicondyle Trapezius Deltoid Supraespinal	Both groups with ↓PPT in the lateral epicondyle, trapezius and deltoid after each day of competition compared to the first day. Female tennis players: Lower PPT in the supraspinatus after the third day of competition; Lower palm grip strength after second, third and fourth day of competition; Increased pain intensity measured using the Visual Analog Scale for pain after second, third and fourth days of competition. Male tennis players presented: Lower PPT in the supraspinatus after the fourth day of competition; Lower palm grip strength after third and fourth day of competition; Increased pain intensity after the third and fourth day of competition.	PPT and grip strength values decreased, while pain intensity increased over the competition days; This tournament sport has a heavy overload schedule that may affect PPT in the upper limbs; It is assumed that consecutive days of competition may contribute substantially to overload injuries in tennis players.

DISCUSSION

Pressure pain threshold, training volume and sports competitions

The training volume in competitive swimmers was directly proportional to PPT[31]. Thus, swimmers with more hours of weekly training had higher PPT, which indicates less mechanical pain sensitivity and possible hypoalgesia induced by the training itself[31]. In non-athletes, aerobic exercise reduces mechanical pain sensitivity in healthy adults[36], and aerobic, isometric and resistance exercises have transient effects on pain reduction in this population[37]. It is worth mentioning that the appropriate dose of exercises to induce hypoalgesia is not clear[37,38], and it has been suggested that for individuals with CP it is more effective to increase the frequency of weekly exercise sessions[38].

Although high training loads are associated with higher injury risks[39], especially when there is a rapid increase in training loads[40], PPT was higher in swimmers who trained more hours per week[39]. Physical training is based on the overload principle, so that in order to increase athlete performance, his activity must exceed the adaptive capacity of the tolerated load[40]. However, the load must be properly managed to avoid the negative effects of training that, when excessive, can lead to overtraining and fatigue; but, when insufficient, results in the athlete not being fully prepared for competition[40]. Possibly, the training performed in the study with swimmers was adequate to develop the physical abilities that enhanced performance and acted preemptively against injuries[39].

The effects of overload can also be observed during sports competitions on consecutive days. One of the included studies[35] measured the PPT during a four-day amateur tennis competition. After the second, third and fourth days of competition, there was a reduction of the PPT at the lateral epicondyle, trapezius and deltoid, as well as a reduction of the PPT at the supraspinatus after the third day of competition in the female group and after the fourth day in the male group. There was also a reduction in palm grip strength after the second, third and fourth days of competition in female athletes and after the third and fourth days in male athletes. In this same period, in both groups there was an increase in pain intensity[35]. Considering the lower muscle mass in women[41,42], it is likely that this accumulation of sequential matches on consecutive days probably generated greater muscle damage in the upper limbs of female athletes compared to male athletes, which reduced the PPT.

Studies evaluating shoulder range of motion in tennis players during two consecutive matches on the same day identified reduced range of motion of the rotations and also reduced strength of the medial and lateral rotators in the dominant limb[43]. These results suggest the accumulation of fatigue with absence of recovery during a sports competition, especially in female athletes, which may predispose the individual to injuries.

Fatigue can be comprehended when the concepts of acute and chronic load are analyzed. The acute load is considered as the total load of practices and/or games in which athletes participated during a week, while the chronic load is the athlete's conditioning state, representing the last three to six weeks of physical training[44]. When there is a high acute load coupled with a low chronic load (low conditioning), the athlete tends to be in a state of muscle fatigue[39]. Thus, the high acute load during the competition period may lead to a state of fatigue following the match days, which can be demonstrated by the reduction in PPT and grip strength, and the increase in pain intensity in tennis players[35].

Pressure pain threshold in swimmers

In addition to the study that correlated training volume with PPT in swimmers, two other studies evaluated this population. These studies obtained conflicting results, while young swimmers aged 8 to 15 years with no complaints did not show changes in mechanical pain sensitivity[32], swimmers aged 18 to 28 years with and without shoulder pain showed central and peripheral sensitization, indicating a possible mechanical hyperalgesia due to the demands of the sports practice[33].

The result in young swimmers without complaints[32] is contrary to that found in a recent systematic review[45], which showed in competitive adolescent swimmers a higher prevalence of shoulder pain, with moderate evidence for association with the volume of swimming training. This lower sensitization in these athletes can be explained by the shorter time practicing the sport, and swimmers with shoulder pain have an average of 11.6 years of practice, while those without shoulder pain have an average of 8.9 years of training[33]. These data corroborate a previous research that found a positive relationship between years of competitive swimming training and reduced supraspinatus tendon thickness, which are self-reported measures of shoulder pain and function[46].

Musculoskeletal adaptations such as reduction of the subacromial space and increase of the shoulder anteriorization posture[47], muscle imbalances in the scapular waist, increase of the internal rotators strength and reduction of the external rotators and supraspinal strength are reported in swimmers[48]. In the long term, these changes may favor shoulder overload injuries[47,49-51], which may explain the central and peripheral sensitization found in swimmers when compared to healthy athletes from other sports[33].

Pressure pain threshold and basketball

Wheelchair basketball athletes with shoulder pain had reduced PPT in all tested areas, in addition to the presence of a higher number of active trigger points when compared to athletes of the same sport and traditional basketball athletes[34]. Shoulder pain is a common condition in these athletes[52], and in men there is an association between shoulder pain and older age, lower functional skills and more years of experience in the sport, while in women, a longer time of practice tends to moderate shoulder pain[53].

Pressure pain threshold and trigger points

The presence of active trigger points (TP) is common in professional basketball players with unilateral shoulder pain[54], similar to what has been found in wheelchair basketball players and swimmers with shoulder pain, who also present a reduced PPT and the presence of central and peripheral sensitization[33,34]. Thus, it is possible that there is a relationship between the presence of active TP, shoulder pain, and low PPT.

The presence of active TP may be related to the presence of central[54] and peripheral[18] sensitization in the studied athletes. In individuals with unilateral subacromial pain syndrome, the presence of bilateral active TP and increased myofascial pain in the affected limb was related to the presence of peripheral sensitization[18]. In subjects with tension headache, a relationship has been established between the number of active TPs in the cervical and shoulder regions and diffuse pain sensitivity (central sensitization)[54].

The small number of publications included in the review can be mentioned as a study limitation, in addition to the fact that the studies included did not evaluate athletes from the same modality, with a predominance of studies with swimmers of various age groups and competitive levels. In addition, a limited number of publications on the theme was identified, making this review

difficult to carry out, even considering the limitations inherent in the methodology used in an integrative review.

This study contributes to a better comprehension of pain and its determinants in athletes, especially swimmers. New studies should be conducted, especially in sports that involve the upper limb in overhead position, taking into account the prevalence and incidence already reported in previous studies about shoulder pain in practitioners of the mentioned sports, both adolescents and adults.

CONCLUSION

Athletes with shoulder pain have lower PPT. However, the PPT in athletes shows conflicting results across sports, indicating the possibility of being sport-dependent. In swimmers, changes in mechanical pain sensitivity seem to be related to weekly training hours, years of sports practice, and age group. In amateur tennis players, consecutive days of competition contributed to reduced PPT in the shoulder and elbow.

AUTHORS' CONTRIBUTIONS

Gabriela de Holanda Leal
Data Collection, Writing - Preparation of the original, Writing - Review and Editing
Luis Ulisses Signori
Writing - Preparation of the original, Writing - Review and Editing
Michele Forgiarini Saccol
Conceptualization, Writing - Preparation of the original, Writing - Review and Editing

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