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Projeto elaborado com vista à obtenção do grau de Mestre em Fisioterapia na Especialidade de Músculo-Esquelética

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ESCOLA SUPERIOR DE SAÚDE

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Intrinsic factors associated with shoulder pain in surfers: a case-control study

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Abstract

Background: The demands of a sport such as surfing are high, paddling is one of the most common movements during a surfing session and therefore the load on the shoulder joint increases. Despite growing evidence regarding surf-related injuries, risk factors should be taking into consideration in a deeper analysis. This study was designed to contribute to greater knowledge of intrinsic factors that may be associated with shoulder injuries.

Objective: The aim of this study is to determine if physical characteristics such as range of motion, shoulder strength, proprioception, scapular dyskinesia, core endurance and pectoralis minor length might be associated with shoulder injuries in surfers.

Methods: Forty-one surfers aged between 18 and 45 years enrolled this study. Firstly, a socio-demographic questionnaire was filled out addressing anthropometric features and previous pain history (three months prior), the second part, an assessment was carried out: range of motion (ROM), shoulder muscle strength, proprioception (joint position sense), core endurance and pectoralis minor length was measured.

Results: Shoulder active range of motion values did not differ between both groups. Normalized shoulder strength and IR:ER ratios for surfers with and without shoulder pain history was not significantly different. End-range position (80º) showed minor relative error scores on surfers who reported previous pain history. There is no correlation between dyskinesia and shoulder pain. Pectoralis minor length did not shown association with a painful shoulder. Symptomatic surfers did show differences in core endurance regarding prone bridge test.

Conclusion: Shoulder pain is a recurring symptom both in competitive and free-surfers. All shoulder parameters: range of motion, strength, dyskinesia, pectoralis minor length, side bridge test, CKCUEST were independent of a history of pain story. End-range (80º) proprioception as well as prone bridge test shown significant differences between surfers who reported previous pain and surfers who did not have previous complains. This study provides a basis for more studies to carry on surf investigation.

Keywords: Surf, shoulder pain, risk factors, injury

There is no conflict of interests to declare

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Introduction

Recreational and competitive surfing has increased in popularity to an estimated 37 million surfers worldwide. The broad availability of wave pools, affiliated with the World Surf League (WSL), has facilitated significant expansion in areas without coastlines (McArthur, Jorgensen, Climstein & Furness, 2020).

In these past years, surfing has grown in Portugal, both at a recreational and competitive level, and it is estimated that this evolution will continue or even increase in the next decade (Almeida, Lains & Veríssimo, 2010).

In 2016, surfing was approved by the International Olympic Committee as a sport included in the 2020 Olympic Games in Tokyo.

As a result of the evolution of surfing over the last thirty years, boards have become even faster and with greater hydrodynamics, which has enabled even more complex and faster maneuvers, inevitably leading to greater physical, physiological and technical demands on surfing, causing more instability for the athlete, increasing the risk of injury and requiring even more efficient neuromotor control mechanisms (Taylor, Bennett, Carter, Garewal & Finch., 2009).

These factors may have contributed to the increased incidence of injuries among surfers (Bazanella *et al*., 2017), as one in three surfers suffers an acute injury each year (Furness *et al*., 2015).

The aerial maneuver is increasingly associated with ankle and knee injuries if the surfer lands on the board incorrectly or falls abruptly (Nathanson, Bird, Dao & Tam-Sing, 2007). This is one of the most "sought after" maneuvers because in terms of points at competition level it is the most valuable.

Although injuries to the lower limbs are the most prevalent due to the complex maneuvers performed, attention has shifted to the activity/movement most practiced during the surf session, which is paddling. Some studies analyzed a surf session and concluded that paddling constitutes between 44% and 61% of the total time of a surf session (Furness *et al*., 2018).

To generate a horizontal vector movement of the board it is necessary to paddle, which depends solely on the synchronous and overhead movement of both shoulders. Since this involves a large portion of time and a repeated movement of extension, abduction and internal rotation, thus creating an overload on the shoulders, it is expected that the shoulder is one of the most injured regions (Langenberg *et al*., 2021).

Factors associated with injury are referred as risk factors, these are often classified either as internal and external (Lysens, 1984) or as intrinsic and extrinsic (Taimela, 1992). Both intrinsic and extrinsic risk factors contribute to injury. Unpredictable ocean environments present unique dangers to surfers; sand, coral reef, rock breaks, water depth, wave size and type, water temperature, presence of other surfers and local marine animals all contribute to the injury risk which is external to the surfer (Base, Alves, Martins & Costa, 2007; Bazanella *et al.*, 1983; Ulkestad, 2016).

Intrinsic risk factors for shoulder injuries in surfers have not yet been largely studied, making it necessary to rely on scientific evidence in large-scale overhead sports, such as swimming, handball, tennis, volleyball or basketball. In a systematic review (Tooth *et al*., 2020) in which shoulder intrinsic risk factors were studied in the sports mentioned above, it is worth highlighting the previous history of shoulder pain (with or without injury), range of motion (ROM), flexibility, muscle weakness, muscle imbalances, scapular dyskinesia, years of practice of sport, BMI among others. Biomechanical factors such as glenohumeral mobility, coordination and technical deficiency can also be considered as risk factors for shoulder injuries in overhead sports (Kibler, Wilkes & Sciascia, 2013). Taking into account swimming, as it is the sport that most resembles surfing, a study carried out in 2015 by Hill, Collins and Posthumus, also concluded that risk factors with moderate levels of certainty included laxity and joint instability, muscular imbalances between internal and external rotation, previous history of shoulder pain or injury and level of competition as risk factors. With low levels of certainty, the following were still reported: years of experience, training volume and intensity, age, distance covered, internal/external rotation strength, scapular strength, scapular dyskinesia, core stability, pectoral and triceps length, inadequate treatment and shoulder flexibility.

In a systematic review Monteiro, Moreira-Pinto & Queiroga (2022) came to the conclusion that competitive surfers have higher injury risk that recreational surfers, being older, having less surfing experience and/or having prior surgical history could also raise the risk of sustaining a surfing injury. The most common types of injury for both competitive and recreational surfers are skin, joint/ligament and muscle/tendon injuries. Being higher percentage of muscle/tendon and joint/ ligament injuries in competitive surfers and a higher percentage of skin injuries in recreational surfers.

One of the roles that physical therapists have, is to address risk reduction and prevention, so identifying individuals risk factors in necessary. Each person has unique physical structure and biomechanics, therefor different type of injuries may occur. Through physical evaluation, physical therapists can identify postural unbalance and muscle weakness and other factors that may predispose the athlete to injurie. The goal of this study was to compare the range of motion, shoulder strength, proprioception, scapular dyskinesia, core stability and pectoralis minor length between surfers with and without previous history of pain in the shoulder.

Materials and Methods

Participants

This case-control study was approved by the Ethics Committee of *Alcoitão School of Heath Sciences*, forty-one surfers (35 males and 6 females,), both professional and recreational, were recruited. Cases were defined as surfers reporting shoulder pain in the previous 3 months and controls were those not reporting shoulder pain in the previous 3 months. Prior to assessment, the surfers completed a consent form (Appendix 1) and a questionnaire (Appendix 2) , that has been particularly developed for this study, which included questions about anthropometric data and previous history of shoulder pain. Participants younger than 18 years, older than 45 years, with less than 4 years of experience, reporting osteoarticular diseases, previous shoulder surgeries, musculoskeletal and neurological conditions, or reporting pain in the day of assessment were excluded. Participants relevant characteristics are included in Table 1.

Data collection was carried out in two stages, firstly by completing the questionnaires previously mentioned and then by performing a physical assessment, no pain was reported by any surfer during the evaluation. Range of motion (ROM), internal (IR) and external rotators (ER) muscle strength, scapular dyskinesia, proprioception (joint position sense), core stability and pectoral length were assessed in surfers reporting or not shoulder pain in the previous 3 months.

Shoulder ROM

Active range of motion was assessed using the *Activforce2* ® device, this device is used to assess range of motion and strength. *Activforce 2* ®, accuracy ranges from: ±1° for angles measured from 0° to 33° and ±3% of the measured angle when > 33°. Shoulder flexion (with elbow maximally extended), extension, abduction, horizontal adduction, internal rotation and external rotation (with the shoulder abducted to 90º, elbow flexion to 90º and prone hand) was measured on a standing position (Kendall *et at*., 1993). The movement was repeated if there were any compensations during the measurement.

Muscle Strength

Bilateral rotation strength was measured using the *Activforce 2* ® handheld dynamometer in a lying prone position, shoulder 90º abducted 90º of elbow flexion with an open palm and neutral shoulder rotation (Falkel *et al*., 1987). For strength measurements, *Activforce* ®2 is accurate within a range of 0.63 kg of applied force, plus or minus 5% of the overall applied force. Three repetitions of each were performed with a rest period of 10s between repetitions, submaximal contraction was encouraged with verbal instruction and maintained for 3 seconds. To avoid any compensation, the free hand was kept on the elbow. The average of the three repetitions was used in this study. Karagiannopoulos, Griech and Leggin (2022) have reported that the device is valid and has high reliability levels across all shoulder motions regardless of tester clinical experience, when assessing shoulder isometric muscle strength.

Scapular Dyskinesis

Scapular movement patterns were assessed using the Scapular Dyskinesis Test (SDT). This test was performed three times, a 1,4 kg (body mass between 36.29 and 68.04 kg) or 2.3 kg (body mass over 68.04kg) dumbbell was used (McClure *et al.*, 2009; Tate *et al*., 2009). Bilateral flexion and abduction was performed simultaneously and the movement was assessed by the examiner from a posterior view and graded accordingly.

SDT test has demonstrated validity and reability in overhead sports specially in swimming and water polo (Tate *et al*., 2009; McClure *et al.,* 2009; Ramiscal *et al.*, 2022) nevertheless other studies have been questioning this validity due to lack of rater experience (Carlsson & Rasmussen-Barr, 2013; Karanicolas *et al.*, 2009; Kottner *et al*., 2011; Rousson, Gasser, & Seifert, 2002), rater blindness to the study and no relation between abnormal or asymmetrical scapular movements to injury (Wassinger, Williams, Milosavljevic & Hegedus, 2015)

Shoulder Proprioception: joint position sense

Subjects attempted to reproduce two shoulder external rotation index angles, 45º and 80º, in 90º shoulder abduction (Herrington, Horsley, Whittaker & Rolf, 2008) The angles were assessed using the *Activforce* ® 2 device. Participants, with their eyes closed, had their shoulder passively rotated to the first of the two target angles and passively returned to the starting position. Immediately after, the participants were instructed to actively attempt to reproduce the target angle. The subjects were asked to say OK and to stop the movement when they thought that the target angle was reproduced. This procedure was repeated 3 times in each angle (45º and 90º) bilateral. From the data 3 repositioning errors were calculated:

Absolute angular error: consisting of the absolute value of the difference between the target range and the achieved range by the subject (Bennell *et al.*, 2005);

Relative angular error: defined as the arithmetic difference between the target range and the range achieved by the subject, reporting directional bias, where negative values indicate an overestimation of the target range, while positive values indicate an underestimation (Bennell *et al*., 2005);

Variable angular error: defined as the standard deviation of the 3 attempts, representing the consistency between attempts (Olsson *et a*l., 2004).

Pectoralis Minor Length

Pectoralis Minor Length was measured with a caliper in a resting position. According to Borstad (2008) using the caliper to a measure the pectoralis minor length is a valid and high accurate method when using he coracoid process and the 4th rib landmarks.

The lower part of the sternal notch and the outer part of the acromioclavicular joint indicate the length of the clavicle. Additionally, the lower middle part of the coracoid process in the deltopectoral groove serves as the attachment point for the proximal pectoralis minor. Following this, the lower front part of the fourth rib, positioned one finger's width away from the sternum, was located, and the participant was instructed to place her index finger on this spot while the researcher measured the distance from the fourth rib to the coracoid process. This measurement reflects the length of the pectoralis minor at rest.

Core Endurance

Core endurance was assessed using prone bridge test, side bridge test and the close kinetic chain upper extremity stability test (McGill, Child & Liebenson, 1990; Schellenberg, Lang, Chan & Burnham, 2007; Goldbeck & Davies, 2000). Participants were timed on the first test while maintaining the position without loss of control of their scapulas resulting in winging. On the second test two pieces of tape were placed on the floor 91,44 cm apart, the subject assumed a push-up position with one hand of each line marked at the floor. Then, for 15 seconds, they lifted each hand sequentially and quickly touched the opposite piece of paper and then return the hand to the original position. The number of repetitions was recorded.

Statistical Analysis

Data analysis was performed using the software IBM SPSS v.26 for Windows, considering a significance level of 5%. Strength values were normalized to body weight (strength/body weight × 100) to determine a relative strength measure expressed as a percentage of body weight, allowing for valid comparison of strength values between surfers of different sizes. From the rotator muscle strength variables, the IR:ER ratio was calculated. The normality of the distribution of variables was tested with the Shapiro-Wilk test. Parametric Student Test were carried out to compare 2 groups in which the assumption of normality is verified (checked using the central limit theorem or using the Shapiro-Wilk test) and non-parametric tests were conducted: Mann-Whitney test for between-group comparisons (e.g., comparing variables between cases and controls). The Qui-square test was used to assess the association between reporting pain in previous 3 months and dyskinesis. Considering that pain might be present in one or two shoulders, the data analysis was conducted at the shoulder level.

Results

The sample consisted of 41 subjects, after meeting eligibility criteria, 6 females and 35 males, with an average age of 29.78 (±9.68) years. The amount of 82 shoulders were assessed which 55 did not reported previous history of pain and 27 reported previous history of pain. Sample characteristics are presented in Table 1 and it is possible to verify that the group was homogenous regarding weight and height but significant differences in age were found, with athletes with previous history of pain being older (p=0.022).

Table 1- Sample characteristics: Biological variables.

		Total	**Surfers with previous history of pain**	**Surfers with no previous history of pain**
Participants (n)		41	23	18
Shoulder Joints (n)		82	27	55
Age (years)	***mean±SD***	29.78±9.69	32.78±9.98	25.94±8.00
	median (IQR)	27(15)	30(18)	24(14)
Height (cm)	***mean±SD***	177.02±7.58	174.87±8.64	175.22±6.80
	median (IQR)	175.00 (10)	175.00(12)	176.00(9)
Weight (kg)	***mean±SD***	71.05± 8.35	71.18±9.36	70.11±7.00
	median (IQR)	70 (9)	70.00 (10)	71.00 (11)
BMI	***mean± SD***	23.08±1.66	23.40±1.65	22.68±1.62
	median (IQR)	22.88(2.23)	23.14(1.53)	22.66(2.79)

SD- Standard deviation; **BMI –** Body Mass Index; **IQR-** Interquartile Range

No significant differences were found when comparing both groups relating to active range of motion (AROM).

Table 2. Shoulder active range of motion measured in degrees (mean±SD)

ROM	Previous history of pain	No previous history of pain	***p value***
Flexion	171.54 ±10.99	170,50±15.26	*0,753* [a]
Extension	58.41±14.86	61.36±20.19	*0.502* [a]
Abduction	160.07±13.39	164.66±15.76	*0.197* [a]
Adduction	53.87±16.98	54.29±14.68	*0.907* [a]
Internal rotation	132.20±32.53	130.40±28.77	*0.799* [a]
External rotation	31.89±15.37	31.19±11.58	*0.819* [a]

[a] Indicates that *T-student* test was performed; **ROM-** Range of motion

Normalized isometric shoulder strength measures and ratio values for surfers with and without previous shoulder pain were normally distributed in Table 3. Surfers with a history of shoulder pain did not demonstrate significant difference in strength or strength ratios when compared to those without previous history of pain.

Table 3. Normalized Isometric shoulder strength (kg/kg), % (mean ±SD)

	Previous history of pain	**No previous history of pain**	***p value***
Internal rotation (norm)	15.07±3.49	15.61±5.27	0.583 [a]
External rotation (norm)	16.30±3.85	15.87±4.65	0.680 [a]
Racio IR/ER	0.96±0.27	1.01±0.30	0.442 [a]

[a] Indicates that *T-student* test was performed; **IR**- Internal rotation; **ER**- External rotation;

Intra-group analysis of the absolute error, relative and variable error regarding joint position sense (JPS) are shown in Table 4. Significant differences were found when comparing the relative error at 80º test angle between surfers with previous history of pain and without history of pain (p=0.043). Surfers who did not experienced previous history of pain overestimating the target angle (negative values) and athletes reporting history of pain underestimating the target angle (positive values).

Table 4. Absolut error, relative error and variable error, º

		Previous history of pain	No previous history of pain	*p value*
Absolut error	45º test angle	5.07±2.96	5.43±3.10	0.558[b]
	80º test angle	10.00±6.00	8.05±5.40	0.144[a]
Relative error	45º test angle	-2.31±6.65	-0.056±7.61	0.193[a]
	80º test angle	-1.62±10.39	3.46±10.65	0.043[a]*
variable error	45º test angle	3.03±4.42	2.88±2.95	0.722[b]
	80º test angle	4.77±4.83	3.68±3.21	0.331[b]

[a] Indicates *T-student* test was performed; [b] Indicates *Mann-Whitney U* Test was performed; * Indicates statistically significant differences.

No association was found between reporting pain and dyskinesia (Table 5) ($\chi^2 = 0.649$; $p = 0.730$).

Table 5. Presence of dyskinesia and previous shoulder history of pain, %

	Previous history of pain	No previous history of pain	*p value*
Normal movement	15 (18,3%)	33 (38.8%)	0.730
Subtle Dyskinesis	10 (12.2%)	16 (19.5%)	
Obvious Dyskinesis	2 (2.4%)	6 (7.32%)	
Total (82)	27 (32.9%)	55 (40.2%)	

Although the mean value of pectoralis minor length is lower in surfers with no previous history of pain no significant differences were observed when comparing the pectoralis minor length between groups. (Table 6)

Table 6. Pectoralis Minor Length, cm

	Previous History of pain	**No previous history of pain**	***p value***
Pectoralis Minor Length	17.01±2.30	16.42±2.39	0.287 [a]

[a] Indicates *T-student* test was performed

Regarding core endurance, three tests were performed: side bridge test, prone bridge test and CKCUEST. Despite mean values are higher, in all testes performed, in the group with previous history of pain, a significant difference was observed in the prone bridge test comparing both groups. The surfers with previous history of pain can last longer in a prone bridge position than the surfers who did not reported pain.

Table 7. Side Bridge Test, s

	Previous history of pain	**No previous history of pain**	***p* value**
Side Bridge	122.00±103.00	94.00±88.00	0.605 [b]

[b] Indicates *Mann-Whitney U* Test was performed

Table 8. Prone Bridge Test (s) and CKCUEST score

	Previous history of pain	**No previous history of pain**	***p* value**
Prone Bridge	172.93±86.31	140.96±65.94	0.049 [a]
CKCUEST	16.89±2.00	16.18 ±2.24	0.168 [a]

[a] Indicates *T-student* test was performed

Discussion

The goal of this study is to identify intrinsic risk factors by comparing range of motion (ROM), muscle strength, scapular dyskinesia, proprioception, core stability and pectoralis muscle length in surfers with and without previous shoulder pain. Studies on surfing are not abundant and therefore information is scarce, challenging the discussion of the results of this study.

Shoulder active range of motion (ROM) was similar in both groups, with no significant differences found. Related to our findings, Kim *et al*. (2019), when comparing active ROM in overhead athletes, also found that there were no differences between healthy participants and those with history of previous injury.

Unlike the results found in this study, Tate *et al*. (2012) found ER ROM to be higher in reporting pain masters swimmers than not reporting pain group. Marcondes *et al*., (2013), Myers, Laudner, Pasquale, Bradley & Lephart (2006) and Shanley *et al*. (2015) found that IR ROM decreased in injury shoulders.

Tate *et al.* (2015) and Beach, Whitney and Dickoff-Hoffman (1992) did also study flexion ROM, although in this study no differences were found, these authors found flexion ROM to be higher in participants reporting previous history of pain. The authors associated hypermobility and age, showing that older participants exhibit larger shoulder flexion ROM, muscular stretching has been reported to exacerbate shoulder symptoms therefor considerations should be taken in further studies regarding shoulder hypermobility, shoulder symptoms and age.

The surfers in this study have shown high values in shoulder ROM evaluation. These results were within expectations, cause being a task-specific movement, surfers have a higher shoulder ROM when comparing to heathy non-athletes (Feijen *et al*, 2020).

No significant differences were found in normalized shoulder strength between both groups. Strength measurement in our study was conducted in Kilograms (kg) making it more difficult to compare to other studies.

McLaine *et al.* (2018), did not find significant differences in normalized strength between history of pain and no history of pain group, although similar to our study, isometric shoulder strength values are higher in surfers who did reported pain.

Unlike this study, Tate *et al*. (2015) and Bak and Magnusson (1997), did found significant differences, being internal rotation (IR) strength values reduced in surfers that had previous history of pain.

Internal rotation strength deficits in surfers that reported previous history of pain might be due to the constant muscle activity of subscapularis muscle during surfing stroke (Pink et *al.*, 1991) and also cause the assessment position was not too comfortable for the athletes.

No significant differences were found in IR/ER ratio in the surfers with and without history of pain, although in the pain-free shoulders the muscle balance was higher, being the IR:ER ratio closer to 1. Low strength IR:ER ratios have been identified as risk factors for injury (Edouard *et al*., 2013; Clarsen *et al.*, 2014).

McLaine *et al.*, (2018), also reached similar conclusions, between swimmers with and without history of shoulder pain, no significant differences in strength ratios were found. When it comes to surfers, and unlike our study, Furnees *et al*. (2018) identified differences when comparing both dominant and non-dominant sides strength ratios being minor non-dominant ratio than dominant. In this paper dominance was not study.

Considering shoulder joint position sense (JPS), absolute error did not show significant differences between both groups. Herrington, Horsley & Rolf (2010), came to a different conclusion when comparing two groups, previously injury to non-injured shoulder, there was significant differences in absolute error score when comparing both angles (45º e 80º). Injured shoulder demonstrated deficit in JPS regardless of joint angle test.

Herrington *et al.* (2010) and Janwantanakul *et al.* (2001), have shown that joint position sense was more accurate (decreased error scores) towards the end of range position (80º) as opposed to mid-range. These findings are supported by this study.

Relative error at 80º angle test showed significant differences between athletes previously reporting history of pain underestimating the target angle (positive values) and athletes without history of pain overestimating the target angle (negative values), authors mentioned above did not study relative errors in JPS.

These results may be attributed to the mechanoreceptors present in the joint capsule and ligaments, which exhibit increased tensile sensitivity at end-range angles, consequently enhancing position sense acuity.

Variable error indicates the subjects consistency in reproducing absolute errors across the three trials.

Variable scores were also assessed by Janwantanakul *et al.* (2001), though the angles assessed were different from this study, significant differences have been found between mid-range and end-range positions, being the end-range position easier to guess (less variable error scores).

Shoulder proprioception (JPS) is required in order to prevent/avoid injury (Green, Comfort & Herrington, 2013). JPS seems to reduce with shoulder fatigue (Matthews *et al.*, 2017; Higson *et al.*, 2018) therefore the results might have a bias considering that surfers that participate in this study had surfed on the evaluation day and the evaluation site was not the extremely calm and quite at times.

No association was found between having dyskinesia and having previous history of pain. The majority of the sample presented a normal scapular movement. This evaluation is subjective and depends on the researcher's assessment.

Our findings were sustained by Gomes *et al.* (2020), Tate *et al.* (2012), Re *et al.* (2023) and Hogan *et al.* (2020), scapular dyskinesis was not significantly associated with having previous shoulder injury. However, Uhl, Kibler, Greenwich & Tripp (2009) reported that an association was found between dyskinesia and shoulder injury.

In pectoralis minor length no significant differences were found between both groups (previous history of pain and no history of pain) similarly to studies lead by Gomes *et al.* (2020), Lewis & Valentine (2007) and Navarro-Ledesma *et al.* (2018). Reduced pectoralis minor length was found, by Tate *et al.* (2012) e Harrington Meisel & Tate (2013) to have association with shoulder pain and disability.

A length reduction of the pectoralis minor muscle has been linked to changes in scapular movement patterns. It is speculated that a shift in the resting position of the scapula could potentially reduce the subacromial space by promoting greater anterior tilt and internal rotation of the scapula (Borstad, 2005).

Core endurance was assessed by three functional tests: prone bridge test, side bridge test and Closed Kinetic Chain Upper-Extremity Test (CKCUWT). Significant differences were found, unlike Tate *et al*. (2012), in

Prone Bridge Test comparing both groups, surfers that did reported pain maintain prone position longer that the surfers that did not reported pain. This could result that athletes with pain exerted more effort during evaluation.

Tate *et al*. (2012) and Paramanidis *et al.* (2023) did not found association between side bridge test and shoulder history of pain. In Pogetti *et al*. (2018) correlations were found between shoulder pain and the trunk muscles endurance, the athletes experiencing symptoms exhibited a reduced endurance time for the lateral flexors of the trunk.

No significant differences were found in the CKCUEST Test. In the study by Tate *et al.* (2012), also no significant differences were observed among any of the groups of swimmers in terms of their performance on the CKCUEST Test. In a recent study by Torabi, Bencke & Van den Tillaar (2024) no differences have been found among handball players playing with shoulder pain, previous pain, and no pain.

Unlike this study, in a study investigating individuals with shoulder damage and healthy individuals using the CKCUEST test, Tucci *et al.* (2014) concluded that there were significant differences and demonstrates adequate reliability for assessing shoulder function in both athletes and general patients with subacromial impingement syndrome.

Apart from the intrinsic factors mentioned throughout this study, there is still some intrinsic factors regarding histological changes within the tendons, biological alterations, mechanical properties, morphology and tendon vascularity (Navarro-Ledesma *et al*. 2018) that should be taken into consideration. Additional physical exercise could also have been considered in this study. Given the small sample size, the findings should not be extrapolated to other population. Further studies should be performed in order to increase scientific knowledge in surf injuries.

Conclusion

No significant differences were found on shoulder active range of motion between surfers who reported pain and surfers who didn't reported previous pain history. Strength profile in internal rotators and external rotators did not show significant differences between both groups. No significant differences were found between both groups when comparing strength ratios IR:ER between both groups. In JPS, considering the end-range angle (80º), surfers who did not experienced previous history of pain tended to overestimate the target angle and athletes reporting history of pain tended to underestimate the target angle. No association was found between dyskinesia and shoulder pain and between pectoralis minor length and previous shoulder pain history. No significant differences were found between both groups when comparing side bridge test and CKCUEST. Surfers that reported pain maintain prone bridge position longer that the surfers that did not reported pain.

Conflicts of Interest

There is no conflict of interest to declare

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APPENDICES

APPENDIX 1

Informed Consent Form

DECLARAÇÃO DE CONSENTIMENTO INFORMADO

Designação do Estudo (em português):

"**Fatores intrínsecos associados a dor no ombro em praticantes de Surf: um estudo de Caso-controlo**

" Eu, abaixo-assinado, (nome completo do participante no estudo) - ________________ ____, compreendi a explicação que me foi fornecida acerca da participação na investigação que se tenciona realizar, bem como do estudo em que serei incluído. Foi-me dada oportunidade de fazer as perguntas que julguei necessárias, e de todas obtive resposta satisfatória. Tomei conhecimento da explicação que me foi prestada e quais os objetivos e métodos. Além disso, foi-me afirmado que tenho o direito de recusar a todo o tempo a minha participação no estudo, sem que isso possa ter como efeito qualquer prejuízo pessoal. Foi-me ainda assegurado que os registos em suporte papel e/ou digital (sonoro e de imagem) serão confidenciais e utilizados única e exclusivamente para o estudo em causa, sendo guardados em local seguro durante a pesquisa e destruídos após a sua conclusão. Por isso, consinto em participar no estudo em causa.

Data: _____/_____________/ 20__

Assinatura do participante no projeto: ____________________________________

Assinatura do Investigador: ____

APPENDIX 2

Socio-demographic Questionnaire

Questionário Socio-demográfico aos Surfistas

Código: _______

1. Dados Pessoais do Surfista

1.1 Idade: _____ anos

1.2 Altura: ____ cm

1.3 Peso: ____kg

1.4 Sexo: Feminino ☐ Masculino ☐

1.5 Stance: Goofy ☐ Regular ☐

1.6 Contacto: ___________________ (Dado importante para posterior avaliação, verifique se está correto)

2. Caracterização da atividade

2.1. Experiência: Free-surfer ☐ Competição ☐

2.2. Há quanto tempo pratica surf?

Entre 1 a 2 anos ☐ Entre 3 a 4 anos ☐ Entre 5 a 6 anos ☐ 7 ou mais anos ☐

2.3 Já alguma vez teve alguma lesão/ dor /desconforto 7 dias seguidos nos últimos 3 meses ou dor pelo menos 1 vez por semana durante 1 mês nos últimos 3 meses em qualquer um dos seus ombros?

Sim ☐ Não ☐

2.4. Consideraria essa dor/ desconforto no complexo do ombro incapacitante no seu dia-a-dia ou a surfar?

Sim ☐ Não ☐

2.5. Procurou algum profissional de saúde para o ajudar nesta questão?

Sim ☐ Não ☐

2.6. Relativamente à lesão/dor/ desconforto mencionado anteriormente, considera que:

Superou completamente ☐ Ainda se encontra com sequelas ☐