Identifying Risk and Protective Factors for Shoulder Pain in Competitive Swimmers: The Role of Stroke Specialty and Competitive Level

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Background: Competitive swimmers are frequently exposed to overuse injuries. The etiology of overuse injuries is not fully understood but has been associated with training volume and biomechanical/anatomical characteristics of each swimmer.

Purpose: To evaluate and identify risk factors associated with shoulder pain and injury in competitive swimmers.

Methods: This prospective cohort study was conducted in collaboration with the Portuguese Swimming Federation (FPN) and included swimmers affiliated with the FPN during the 2023–2024 season. A questionnaire was administered to collect demographic and anthropometric data, training habits, injury history, and the presence of shoulder pain.

Results: A total of 167 athletes were included. Of those, 116 (69%) reported substantial interfering shoulder pain (SIP) during the 6-month study period, while 51 (31%) reported substantial shoulder injury (SSI). The incidence of SIP varied between 34% and 50%, and that of SSI ranged between 19% and 21%. Master's swimmers showed a decreased risk of SIP (p=0.008, odds ratio [OR]=0.243) compared with state competitive swimmers. Backstrokers demonstrated a decreased risk of SIP (p=0.003, OR=0.197) compared with swimmers with other stroke specialties. Injury history and distance swam per training (km) proved to be risk factors for the presence of SSI (p=0.007, OR=4.283 and p<0.001, OR=2.224, respectively).

Conclusion: Stroke specialty (backstroke) and competitive level (master's) play protective roles in the development of SIP. History of injury and distance swam per session were risk factors for SSI. There is a pressing need to develop preventive programmes and attentive measurement tools to evaluate shoulder pathologies among swimmers.

What this study adds: For the first time, we demonstrated a protective association of backstroke and master's level swimmers with the presence of short-term shoulder pain. This study also demonstrated that the training volume and a history of shoulder injury are directly associated with the presence of long-term shoulder pain among swimmers.

How this study might affect research, practice or policy: This study highlights the pressing need to develop specific preventive programmes and measurement tools for evaluating shoulder pathologies among swimmers.

Study design: Prospective cohort study

Level of evidence: Level II

Keywords: Shoulder Pain; Swimmers; Swimmer's Shoulder; Swimming; Swimming Injuries.

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Introduction

Swimming is one of the most popular sports worldwide [1]. Although traumatic injuries are rare, swimming is the sport that is most prone to overuse injuries [2][3][4]. This is related, at least in part, to the fact that a swimmer performs, on average, approximately 4000 strokes per training session, accounting for approximately a million strokes in a single season [5]. In addition, there are complexities and idiosyncrasies specific to each swimming style and intrinsic and extrinsic factors for the athlete that can increase the risk of injury [6][7].

The etiology of overuse injury is still not fully understood. This is partly because of the complexity of the pathology and the lack of investment in research in this area. The lack of knowledge about the etiology and associated factors contributes to the fact that there continues to be no scientifically proven preventive model in sports [8].

Therefore, this study aimed to contribute to a better understanding of shoulder pain in swimmers at all competitive levels by evaluating the incidence of pain and shoulder pathology in swimmers, as well as the risk factors and their relationship with the training phase. We hypothesized that there would be a positive correlation between greater training volume/intensity and the prevalence of shoulder pain and injury.

Materials and Methods

Study design and population

This prospective cohort study was conducted in competitive swimmers affiliated with the Portuguese Swimming Federation (FPN) during the 2023–2024 season.

Swimmers were classified by different competitive levels based on the competitions they were eligible to participate in with the required time limits: state level, national level, international level, and Olympic level. Swimmers competing solely in the master's competitions were classified as master's level swimmers.

The FPN promoted the study with the participants in national competitions and social media.

Swimmers were asked to complete a monthly questionnaire to report their training and competition diaries and the presence of pain. When forms were not submitted, swimmers were contacted via e-mail.

Participants could withdraw from the study at any time.

Data collection

The swimmers completed a baseline questionnaire about their demographic and anthropometric characteristics, training habits, competition characteristics, and injury history (**Supplementary File 1**).

Since the definitions of pain and injury can be arbitrary, shoulder pain definition was defined *a priori*, as substantial interfering shoulder pain (SIP) in the shoulder, based on a previously established definition [9]. The presence of SIP was considered in athletes who reported a moderate to severe impact on their sports performance during training and/or competition.

Substantial shoulder injury (SSI) was defined as any episode of SIP lasting at least 2 consecutively months [6]. These definitions were used to evaluate the potential risk factors for short- and long-term injuries.

Statistical analysis

Preliminary univariate logistic regression analyses were performed to identify the variables associated with SSI and SIP. Variables with p-values <0.05 were retained for multivariate analyses. The independent predictors of shoulder pain and/or injury (SSI and SIP) were determined using forward stepwise binary logistic regression analysis. The collected data were subjected to statistical analysis using Statistical Package for the Social Sciences (version 29; IBM Corp., Armonk, NY), and the test results were considered statistically significant at p <0.05, with a 95% confidence interval.

The required sample was met, with at least 10 athletes with pain per risk factor tested [10][11].

Statistical analysis was conducted according with the Checklist for statistical Assessment of Medical Papers (the CHAMP statement) [12].

Ethics considerations

All patients provided informed consent. This study was approved by the Ethics Committee of ICVS – Life and Health Sciences Research Institute (reference number: CEICVS 163/2023), and all participants provided informed consent.

The data supporting the findings of this study, including demographic and anthropometric characteristics, training habits, competition characteristics, and injury history of participants, are stored by the main researcher.

Due to privacy concerns and ethical considerations, the data will not be publicly available and will only be accessible to the research team. All athlete information was encoded using anonymous codes to ensure privacy. The data will be deleted following the completion of the research.

Only supplementary tables, excluding any identifying information about the athletes, will be made available upon reasonable request.

Reporting patient and public involvement in research

The FPN promoted the study with the participants in national competitions and social media. Swimmers were asked to complete a monthly questionnaire to report their training and competition diaries and the presence of pain.

When forms were not submitted, swimmers were contacted via e-mail. Participants could withdraw from the study at any time.

Results will be disseminated to all study participants and partners via email. The authors will disseminate outcomes and conclusions of this work via conference presentations and scientific publications.

Equity, diversity, and inclusion in research

Our study includes equal numbers of both women and men, representing athletes of all ages, demographics, and competitive levels. The research was conducted by a multidisciplinary team involved in a specialized line of research in Sports Medicine and Swimming. Additionally, the team comprises medical students, physiotherapists, doctors, and academic researchers.

Results

Swimmer characteristics

The questionnaire was answered by 167 swimmers, 40 of whom competed at the state level, 85 at the national level, five at the international level, four at the Olympic level, and 33 at the master's level. Compliance with the questionnaires decreased over 6 months, with only 85 swimmers responding in the last study survey.

Participants' average age was 26 years (range, 11–75 years) (**Table 1**). The preferred stroke for 43% (n=72) of the swimmers surveyed was front crawl, followed by breaststroke (20%, n=33), butterfly (19%, n=34), and backstroke (16%, n=28). Most swimmers (74%, n=124) preferred sprint distances (50 and 100 m). Among the swimmers surveyed, 27% (n=46) reported a history of shoulder injury that interfered with sports practice.

Training habits

Most athletes (59%, n=98) described the first month as a time of 'normal training load', 40 athletes (24%) described it as a time of 'increased training load', and 29 athletes (17%) described it as a period of reducing load to prepare for the competition, i.e. 'taper' (**Table 2**). On average, the athletes completed a 3.9-km per training session, of which 500 meters using paddles. Only 24% (n=40) of the participants performed ≥15 minutes of a warm-up before the water training, and 50% (n=84) of the participants did not perform any type of stretching after training.

		State Level n= 40		National Level n=85		International Level n=5		Olympic Level n=4		Master's Level n=33		Total Female n=83		Total Male n=84		Total n=167	
Age		19±6 (20)		19±5 (20)		17±2 (19)		26±7 (26)		50±11 (52)		20±11 (25)		20±16 (27)		20±14 (26)	
BMI		20.97±4.16 (21.75)		21.26±3.19 (21.92)		20.31±1.05 (21.81)		22.04±0.96 (22.28)		24.22±4.18 (24.59)		21.30±2.76 (21.76)		22.63±5.14 (23.08)		21.72±3.86 (22.41)	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Preferred stroke	Front Crawl	22	55%	29	34%	4	80%	1	25%	16	49%	33	38%	39	47%	72	43%
	Butterfly	6	15%	16	19%	1	20%	2	50%	8	24%	15	18%	18	22%	33	20%
	Backstroke	4	10%	19	22%	0	0%	1	25%	4	12%	18	22%	10	12%	28	17%
	Breaststroke	8	20%	21	25%	0	0%	0	0%	5	15%	18	22%	16	19%	34	20%
Specialty	Sprint	36	90%	59	70%	1	20%	3	75%	25	76%	72	86%	52	63%	124	74%
	Mid Distance	2	5%	13	15%	2	40%	0	0%	2	6%	5	6.0%	14	17%	19	11%
	Distance	2	5%	13	15%	2	40%	1	25%	6	18%	7	8%	17	20%	24	15%
History of shoulder injury	No	30	75%	66	78%	4	80%	1	25%	20	61%	58	69%	63	76%	121	73%
	Yes	10	25%	19	22%	1	20%	3	75%	13	39%	26	31%	20	24%	46	27%

Table 1. Participant Characteristics. Data are presented as median =/- interquartile range (mean) or frequency and percentage.

Presence of pain

During the first month of the evaluation, 47% (n=78) of swimmer reported the presence of pain, while 10% (n=17) reported the presence of discomfort/other sensation during training (**Table 3**). Of the 95 athletes with pain or discomfort, 42% (n=40) of them did not seek a solution through medication or consultation with a healthcare professional. The stroke in which swimmers reported the greatest level of pain was front crawl followed by butterfly.

In the first evaluation, 45% (n=75) of the swimmers reported pain that interfered with sports performance during training and/or competition, and they were classified as having SIP (**Table 4**). During the 6-month follow-up, 69% (n=116) of the swimmers reported pain classified as SIP, whereas 31% (n=51) reported pain classified as SSI. The percentage of SIP varied between 34% and 50%, and the percentage of SSI ranged between 19% and 21%.

Predictors of SIP

Preliminary univariate logistic regression analysis revealed a significant association between the following variables and the presence of SIP: age, competitive level, backstroke-dominant style, distance swam per session (km), and duration of warm-up time per training (**Table 5**). However, out of the variables identified in the preliminary regression, the multivariate logistic regression analysis identified as independent predictors of SIP the variables master's level (odds ratio [OR]: 0.243, p=0.008) and backstroke-dominant style (OR: 0.197, p=0.003). The model had a Nagelkerke R2 value of 0.184 and a p-value of <0.001.

Predictors of SSI

Preliminary univariate logistic regression analysis revealed a significant association between the following variables and the presence of SSI: injury history, training load, and distance swam per training (km). All three variables identified in the preliminary regression were identified as independent predictors of SSI in the multivariate logistic regression analysis (**Table 6**). History of injury, increased training load, and distance swam per session (km) had ORs of 4.283 (p=0.007), 0.075 (p=0.002), and OR of 2.224 (p=<0.001), respectively. The model had a Nagelkerke R2 value of 0.401 and a p-value of <0.001.

		State Level n=40		National Level n=85		International Level n=5		Olympic Level n=4		Master's Level n=33		Total Female n=83		Total Male n=83		Total n=167	
Distance swam per session (km)		3.0±1.5 (3.3)		4.6±2.0 (4.6)		6.0±3.0 (5.8)		5.0±1.5 (5.3)		2.0±0.5 (2.3)		4.0±2.2 (4.0)		4.0±2.5 (3.8)		4.0±2.5 (3.9)	
Distance swam with paddles (m)		400±800 (440)		600±600 (829)		1500±900 (1120)		1375±1750 (1250)		400±539 (300)		400±800 (658)		600±600 (743)		500±700 (701)	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Training load	**Taper**	8	20%	18	21%	2	40%	0	0%	1	3%	13	15%	16	19%	29	17%
	Normal	28	70%	39	46%	0	0%	3	75%	28	85%	52	62%	46	55%	98	59%
	Increased	4	10%	28	33%	3	60%	1	25%	4	12%	19	23%	21	25%	40	24%
Number of gym sessions per week	**0**	20	50%	19	22%	3	60%	0	0%	23	70%	34	40%	31	37%	65	39%
	1	5	13%	5	6%	0	0%	0	0%	4	12%	6	7%	8	10%	14	8%
	2	8	20%	25	30%	0	0%	0	0%	2	6%	14	17%	21	25%	35	21%
	3	6	15%	24	28%	2	40%	2	50%	3	9%	16	19%	21	25%	37	22%
	4+	1	3%	12	14%	0	0%	2	50%	1	3%	14	17%	2	3%	16	10%
Duration of warm-up (on dry land)	**0 min**	10	25%	19	22%	0	0%	1	25%	20	61%	26	31%	24	29%	50	30%
	5 min	8	20%	23	28%	3	60%	0	0%	10	30%	17	20%	27	33%	44	26%
	10 min	10	25%	19	22%	1	20%	1	25%	2	6%	15	18%	18	22%	33	20%
	15+ min	12	30%	24	28%	1	20%	2	50%	1	3%	26	31%	14	16%	40	24%
Duration of stretching (after swimming)	**0 min**	21	53%	38	45%	2	40%	1	25%	22	67%	45	54%	39	47%	84	50%
	5 min	5	12%	27	32%	3	60%	1	25%	6	18%	15	18%	27	33%	42	25%
	10+ min	11	28%	11	12%	0	0%	1	25%	4	12%	16	19%	11	13%	27	17%
	15+ min	3	7%	9	11%	0	0%	1	25%	1	3%	8	9%	6	7%	14	8%

Table 2. Training Habits among Swimmers. Data are presented as frequency and percentage.

		State Level n=40		National Level n=85		International Level n=5		Olympic Level n=4		Master's Level n=33		Total Female n=83		Total Male n=83		Total n=167	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Presence of pain	No Pain	15	38%	31	36%	2	40%	2	50%	22	67%	35	42%	37	45%	72	43%
	Pain	22	55%	43	51%	2	40%	1	25%	10	30%	40	48%	38	46%	78	47%
	Discomfort	3	8%	11	13%	1	20%	1	25%	1	3%	9	11%	8	10%	17	10%
Pain by swimming stroke	Front Crawl	11	44%	17	33%	1	50%	2	100%	3	27%	22	46%	12	28%	34	37%
	Butterfly	7	28%	19	37%	1	50%	0	0%	2	18%	14	29%	15	35%	29	32%
	Backstroke	1	4%	5	10%	0	0%	0	0%	0	0%	4	8%	2	5%	6	7%
	Breaststroke	0	0%	0	0%	0	0%	0	0%	2	18%	0	0%	2	5%	2	2%
	None	6	24%	10	20%	0	0%	0	0%	4	36%	8	17%	12	28%	20	22%
Medication for pain	No	23	92%	42	82%	3	100%	2	100%	10	91%	43	90%	37	84%	80	87%
	Yes	2	8%	9	18%	0	0%	0	0%	1	9%	5	10%	7	16%	12	13%
Consultation with a healthcare professional for pain solution	No	12	48%	23	45%	0	0%	1	50%	3	27%	22	46%	17	40%	39	43%
	Yes	13	52%	28	55%	2	100%	1	50%	8	73%	26	54%	26	60%	52	57%
No action for pain solution		12	48%	23	43%	1	33%	1	50%	3	27%	22	45%	18	39%	40	42%

Table 3. Presence of Pain among Swimmers. Data are presented as frequency and percentage.

	State Level		Nacional Level		International Level		Olympic Level		Master's Level		Total					
											Female		Male		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Month 1																
Total	40		85		5		4		44		84		83		167	
SIP	23	58%	42	49%	1	20%	1	25%	8	24%	40	48%	35	42%	75	45%
Month 2																
Total	26		53		2		4		20		56		49		105	
SIP	11	42%	25	47%	0	0%	2	50%	9	45%	26	46%	21	43%	47	45%
SSI	7	27%	19	36%	0	0%	0	0%	3	15%	18	32%	11	22%	29	28%
Month 3																
Total	21	1	46		1		1		19		45		43		88	
SIP	9	43%	23	50%	0	0%	1	100%	11	58%	26	58%	18	42%	44	50%
SSI	2	10%	12	26%	0	0%	1	100%	8	42%	13	29%	10	23%	23	26%
Month 4																
Total	22		46		3		2		17		48		42		90	
SIP	8	36%	14	30%	3	100%	2	100%	8	47%	19	40%	16	38%	35	39%
SSI	4	18%	5	11%	0	0%	1	50%	7	41%	9	19%	8	19%	17	19%
Month 5																
Total	20		40		1		3		18		44		38		82	
SIP	6	30%	12	30%	0	0%	2	67%	8	44%	20	45%	8	21%	28	34%
SSI	5	25%	6	15%	0	0%	1	33%	6	33%	11	25%	7	18%	18	22%
Month 6																
Total	18		37		2		2		19		39		39		78	
SIP	9	50%	14	38%	1	50%	2	100%	8	42%	19	49%	15	38%	34	44%
SSI	6	33%	6	14%	0	0%	1	50%	7	37%	12	31%	7	18%	19	24%
Total																
Total	40		85		5		4		44		84		83		167	
SIP at least 1 time	29	73%	59	69%	4	80%	4	100%	20	61%	59	70%	57	69%	116	69%
SSI at least 1 time	13	33%	25	29%	0	0%	2	50%	11	33%	31	37%	20	24%	51	31%

Table 4. Presence of SIP and SSI among Swimmers. Data are presented as frequency and percentage. SSI, substantial shoulder injury; SIP, substantial interfering shoulder pain.

Variable	Category	p-value	OR (95% CI)	R^2
Predictive Model		**<0.001***		0.184
Competitive Level	State (ref.)	**0.034***		
	Nacional	0.770	0.887 (0.398–1.979)	
	International	0.120	0.160 (0.016–1.616)	
	Olympic	0.452	0.392 (0.034–4.505)	
	Master's	**0.008***	0.243 (0.086–0.688)	
Preferred Swimming Stroke	Front Crawl (ref.)	**0.008***		
	Butterfly	0.072	0.436 (0.176–1.076)	
	Backstroke	**0.003***	0.197 (0.068–0.570)	
	Breaststroke	0.886	1.065 (0.447–2.540)	

Table 5. Predictive Model of SIP. * Statistically significant, p<0.05. SIP, substantial interfering shoulder pain; OR, odds ratio; CI, confidence interval; ref., reference.

Variable	Category	p-value	OR (95% CI)	R^2
Predictive Model		**<0.001***		0.401
History of Injury	No (ref.)			
	Yes	**0.007***	4.283 (1.475–12.436)	
Training Load	Taper (ref.)	**0.007***		
	Normal	0.075	0.337 (0.102–1.116)	
	Increased	**0.002***	0.075 (0.015–0.383)	
Distance Per Session (km)		**<0.001***	2.224 (1.428–3.464)	

Table 6. Predictive Model of SSI. * Statistically significant, p<0.05. SSI, substantial shoulder injury; OR, odds ratio; CI, confidence interval; ref., reference.

Discussion

The most important finding of this study was the observation that backstrokers and master's level swimmers had a decreased risk of shoulder pain compared with their counterparts. Moreover, our study hypothesis was confirmed, as a positive association was found between the distance swam per training session (km) and the presence of SSI. In addition, results demonstrated that shoulder pain is a common problem among swimmers that affects the quality of swimmers' training and performance.

Participants

In total, 167 athletes from different clubs and competitive levels were included. The minimum age registered was 11 years, and the maximum age was 75 years (master's level). The inclusion of younger athletes (lower competitive levels) and older athletes (highest competitive level) made it possible to observe trends at all competitive levels and ages, thereby establishing more comprehensive conclusions for all swimmers.

Incidence of SIP and SSI

During the 6-month study period, the incidence of SIP varied between 34% and 50%, whereas that of SSI ranged between 19% and 21%. These results are similar to those observed in previous studies [6][17][18]. Other studies have reported pain incidence ranging from 40% to 91% [3]. However, most of these studies use a binary classification of pain (present/absent), whereas our definition, differs, considering the extent to which pain impacts athletic performance.

Among swimmers who experienced pain, 42% did not use any medication or seek help from a healthcare professional. Thus, two of the five swimmers with shoulder pain had their competitive performance affected without an established recovery plan. This situation is partly attributable to the lack of support within the sport, as many athletes do not have access to a doctor or physiotherapist when injured. Furthermore, athletes may avoid seeking help due to the fear of being sidelined or losing financial and institutional support.

The Role of Competitive Level and Stroke Specialty

Master's level proved to be an important preventive factor for SIP. Master's level swimmers were 4.116 times less likely to have SIP than state level swimmers. The reason for this association is unclear, and it is important to highlight that this effect is independent of training load and age. This suggests that Masters swimmers may be influenced by a 'survivor bias.' Previous studies that did not include master's level swimmers showed an association between higher competitive levels and shoulder pain [13][14][15][16]. This could be due to the fact that they did not abandon the sport usually since the childhood, which may have allowed them to develop better technique, or because they are more resilient to injuries. This resilience may stem from anatomical adaptations that occur over time or other contributing factors.

Our study showed that the dominant stroke in competitive swimmers was an important predictor of shoulder pain. However, backstrokers had a significantly lower risk of SIP than other swimmers. This reveals a discrepancy with a previous study that reported an association between specialty in backstroke and shoulder pain [2]. However, this same study did not quantify these protective or adverse effects. Since backstroke is the only stroke performed with the active part of the stroke with the shoulder in external rotation, biomechanical assessment of swimmers is necessary to better understand the association between backstroke and a lower incidence of pain.

Risk Factors for SSI

A history of injury proved to be an independent predictive factor for the presence of SSI. This result is consistent with that in a previous study [6] and demonstrates that shoulder injuries in swimmers are recurrent and chronic [19]. However, the reason for their recurrence remains unclear. This may be due to structural changes that compromise joint integrity and stability, ineffective injury recovery programmes, or re-exposure to risk factors.

The effect of distance swam per session (km) and shoulder injury has been a discordant topic in previous studies. Although previous studies suggest that repetitive over-head movements are the basis of the pathology [5][14][15][16], other studies did not find an association between the distance swam per training and the presence injury [6][20][21]. Here, we found a positive association between distance swam per session (km) and the presence of SSI. Nevertheless, other factors may also play a role in the association between the training volume and shoulder pain. Although some studies have demonstrated an association between biomechanical changes, technical errors caused by swimmers, and the presence of shoulder pathology [6][22][23][24][25][26][27], further research is needed to fully understand this association.

The predictive effect of training load was significant for the presence of SSI, but with an effect opposite to that expected. Additionally, increased training load had a protective association with the presence of SSI. These results are different from what we find in previous studies [5], and contradict the effect of distance. However, these results can be explained by the study design. Swimmers answered a questionnaire at the end of each month; thus, the description of the load may have been biased towards the last weeks of that month. Furthermore, it is expected that a swimmer with impeding pain for two consecutive months will feel forced to reduce their training volume and thus report a decreased training load.

Clinical Implications

This study revealed the significant gaps in current clinical practice in the management of swimming-related shoulder injuries. The diagnosis and monitoring of shoulder injuries in swimmers are limited to the athletes' perception of their ability, and there are no specific scores or patient-reported outcome measures for this sporting activity that allow for a practical and targeted assessment of each athlete's swimming [27].

The understating of the risk and protective factors is essential to aid in the development of diagnostic and management of these injuries. Further research with biomechanical assessment of athletes is needed to better understand the association between backstroke preference and prevention measures against shoulder pain.

Limitations

The use of a self-report questionnaire has its limitations but proves to be very useful in understanding the relationships between intrinsic and extrinsic risk factors for athletes and the presence of SIP or SSI. Still, it is important to note some limitations of the present study. First, swimmers who had previously experienced some type of shoulder injury and/or pain were more likely to answer the questionnaire, thus potentially overestimating the incidence of the injury. Second, no diagnostic examinations were performed. Although many athletes reported diagnoses made by health professionals, SIP and SSI diagnoses were based on each swimmer's report and the interference of pain/injury in sports performance. Finally, a decrease in participants' adherence was observed over time, with only 85 swimmers responding in the last month of the study.

Conclusions

Shoulder pain is a common problem that greatly affects swimmer performance; yet, it is often ignored by swimmers and their teams.

This work demonstrated that stroke specialty and competitive level play key roles in the development of SIP, results demonstrated that Swimmers at master's level and those with a backstroke specialty have a protective association with a decreased risk of SIP. The most important predictor for the presence of SSI was distance swam per training (km); the more kilometers swam, the greater was the risk of injury. Furthermore, this study demonstrated that injury recurrence was considerable, with an increased risk of 4.28 among swimmers with a history of injury.

The classification and qualification of shoulder pathology in swimmers are complex, and there is a need for concrete measures to facilitate the evaluation, diagnosis, classification, and monitoring of such athletes so that effective preventive programs can be implemented.

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Author contributions

NS and DNS contributed to the study conception and design, performed and interpreted the analyses, drafted the final manuscript, and critically reviewed it for important intellectual content. ES, RE, DM, BC, EM, and HP contributed to the study design, data interpretation, and revised the manuscript for important intellectual content.

All authors agree to be accountable for all aspects of the work, approved the final manuscript for submission, and took the responsibility for the integrity of the work as a whole, from inception to finished article.

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Conflict of interest statement

The authors declare no conflicts of interest in the authorship or publication of this work.

Supplementary Materials

Supplementary File 1 - Questionnaire

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